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MEDALS OF THE NATIONAL ACADEMY OF SCIENCES[1]

PRESENTATION OF THE JAMES CRAIG WATSON MEDAL TO ERNEST WILLIAM BROWN

THE problems of motion in the solar system have challenged the ingenuity of the greatest mathematicians and theoretical astronomers. Of those who have contributed to their solution none has attained the precision in representing the observed positions of the moon that Ernest W. Brown has achieved in his well-known theory. In 1907 he received the Gold Medal of the Royal Astronomical Society on the completion of the literal and numerical theory.

At that time about a dozen lunar theories had been produced. Of these that of Hansen held its place in the nautical almanacs. Before Brown's theory could replace that of Hansen it was necessary for him to make his theory accessible in the form of tables. The invention and testing of practical devices for this purpose engaged him for a number of years until the tables appeared in 1920. Hansen's approximate theory included 500 terms as against Brown's 1,500 terms. An ephemeris based on his theory would have required a hundred to two hundred hours' work for a single position. The numerical operations necessary for an hourly ephemeris extending over a year would demand at least a million hours of work. On the basis of a 40-hour week and a 50-week year, medical men would have to extend the span of life of a single computer to five hundred years to enable him to accomplish the task. With the aid of the tables the task can now be accomplished by a single computer in from six to nine months.

On the achievement of this second step in his lunar theory Dr. Brown was awarded the Bruce Gold Medal of the Astronomical Society of the Pacific. His tables have been uniformly used in the nautical almanacs since 1923 and predicted the 1923 eclipse with surprising accuracy. The honors which Brown has received were prompted not only by his lunar theory, although he had made it his principal task since 1890.

[1] Presented at the dinner of the academy, Washington, D. C., April 27, 1937.

Admirable accounts of his many other achievements were printed in the *Monthly Notices* of the Royal Astronomical Society and in the *Publications* of the Astronomical Society of the Pacific on the occasion of the award of the medals.

The third stage of his lunar theory, on which Brown is still engaged, has as its main objective the explanation of the minor discrepancies which have revealed themselves between the tabulated and the actual motion of the moon. At the same time his genius has conquered a variety of other hitherto unsolved problems based on Newton's law of gravitation. All these endeavors have led to new and significant results. The award of the Watson Medal therefore is based on his notable contributions to gravitational theory in general rather than on the specific achievement of the lunar theory.

In 1907 he had produced the most accurate value of the secular term in the moon's mean motion, but there remained unexplained well-marked deviations in the longitude of a fairly systematic character. There were also unexplained departures in the motion of the perigee and of the node of the moon's orbit amounting to the really small trifles of 17″ and −12″, respectively, per century. These he has practically wiped out by the inclusion of still further significant terms in his expansions. This last achievement was an unexpected by-product of a remarkable investigation on the stellar problem of three bodies, of which the third part on the motions of the apse and node, with applications to the moon, was published as recently as last December.

In 1924 he hit upon the real character of the occasional deviations in the longitude of the moon by correlating them with those of the sun and thereby was able to eliminate a gravitational cause external to the earth for the deviation of this type of the moon, sun, Mercury and Venus. This led to the discovery of the variability of the rotation of the earth and to the establishment of the moon as a more perfect timepiece than the earth. Of greatest importance are his demonstrations of the effect of the moon on the rate of the almost perfect Shortt clocks. At present he is engaged with Professor W. J. Eckert, of Columbia University, on a new numerical verification with the use of the modern computing machines.

Among his many other achievements, time permits me to mention only a few. He has produced a successful general theory of the Trojan group of minor planets which oscillate about the third corner of an equilateral triangle with sides equal to the distance of Jupiter from the sun. This theory is outstanding as regards originality and elegance of treatment and represents the observed motions of the planets of the group more perfectly than any other.

In the more general field of celestial mechanics he has made many significant contributions, including a general theory of resonance which he has applied successfully to the explanation of the gaps in the distribution of the mean motions of minor planets. His work on the Fourier series, on the development of the perturbative functions, his special forms of separated differential equations, which made it possible to integrate independently one class of terms irrespective of the others, and other contributions mark a new epoch in the general theory of perturbations. He should also be mentioned his theory of the eighth satellite of Jupiter. And last, I must mention his conclusion that the discovery of the planet Pluto was not based on theoretical predictions, a conclusion which he reached after a highly ingenious and strictly mathematical discussion of the conditions of this remarkable case.

Such is a brief and wholly inadequate record of our medalist's achievements. The academy may justly be proud to count him among its members and to be able to honor him by the bestowal of the Watson Medal.

A. O. LEUSCHNER

UNIVERSITY OF CALIFORNIA

PRESENTATION OF THE HENRY DRAPER MEDAL TO C. E. KENNETH MEES

IN 1872 Dr. Henry Draper secured the first successful photograph of the spectrum of a star, and he also was first to secure any photographic record of a nebula . . . the great gaseous cloud in Orion. Thus we see he was a pioneer in the application of photography to astronomy and that he was possessed of an eagerness for improved means for observing the heavens.

Dr. Draper's brilliant pioneering work was unfortunately interrupted by his untimely death in 1882, before he was privileged more than a glimpse of the great advantages the application of photography was to bring to the study of the heavens. However, his widow, wishing to stimulate growth in this new field opened by her husband, established the Henry Draper fund with this academy, and indicated ways the income of the fund might be employed to stimulate study in this new field.

It then appears peculiarly fitting that the academy in this Henry Draper award is recognizing and encouraging the development of photography as applied to astronomy. And it is a pleasure to mention some of the grounds for the academy's awarding the Henry Draper Medal, this evening, to Dr. C. E. Kenneth Mees, director of the Research Laboratory of the Eastman Kodak Company, Rochester, N. Y.

Dr. Mees has devoted his life to the development of the theory and the perfection of photographic processes and materials. His early prominent piece of

work, "Investigations on the Theory of the Photographic Processes," published in 1907 in collaboration with Sheppard, has since been a classic on the subject. This gave him wide distinction, and he was called to America in 1912, where since then he has been continuously occupied in this field of endeavor at the Eastman Kodak Research Laboratory, of which he has been the director.

Let us recall that at the beginning of the present century it was hardly possible in astronomy to photograph a spectrum range of more than about 2,700 Angström units, *i.e.*, from 3,300–6,000 A. But to-day fully twice that length of spectrum (*i.e.*, from 6,000 to 12,000 A. in the infra-red) has been added. Much of this great gain has resulted from the development of emulsions and sensitizers at the hands of Dr. Mees.

Surely we would give enthusiastic welcome to a new telescope of double the power of any existing instrument, but would not astronomy gain far more if the power of our photographic plates were to be doubled, for such would in effect be doubling the power of *all* telescopes.

But Dr. Mees's wide extension of the photographable spectrum into the longer wave-lengths carries even greater scientific importance than might at once be evident, for it brings us knowledge of a vast new portion of the energy of the stars. And this means our knowledge of the heavenly bodies may now be builded upon this broader foundation. To point an example, the successful photography of the red and infra-red of the spectra of the planets has brought new knowledge of notable value on the constitution of the atmospheres of the planets.

In accomplishing these and other advances for photography our medalist has contributed to the general progress of science, as well as to astronomy in particular. Incidentally he has built up the excellent Research Laboratory of the Eastman Kodak Company. Thus for thirty years he has carried on with marked ability and skilful technique fundamental researches.

It is, therefore, a pleasure, on behalf of the Draper Committee, to present Dr. C. E. Kenneth Mees for the high honor of the Henry Draper Award.

FRANK SCHLESINGER

YALE OBSERVATORY

PRESENTATION OF THE AGASSIZ MEDAL TO MARTIN KNUDSEN

MARTIN KNUDSEN while a very young man had an experience that largely determined his scientific activities for the rest of his life. In 1895 and 1896 he undertook the physical investigations on board the Danish cruiser *Ingolf* in the seas around Iceland and Greenland. At the time of the first expedition Knudsen was 24 years old and he said, "I was totally unacquainted with hydrographical work, and the knowledge I had occasion to acquire of hydrographical literature before our departure in 1895 was but a trifle." During the first voyage he made observations on surface and subsurface temperatures, determined the specific gravity of water samples and the amount of chlorine in them, and took samples of water in bottles and in exhausted glass ampules. During the second voyage, as the water was immediately analyzed for contained gases, it was not necessary to collect samples in evacuated glass ampules. This program sounds simple, but there were difficulties. First, the thermometers for recording subsurface temperatures were inadequate—Knudsen thereupon improved the thermometers. He discarded as too crude the attempts to determine the specific gravity of sea water by means of hydrometers and further developed the method of chlorine titration. He also developed methods for making gas analyses on shipboard, so that the needed analyses were made immediately after the water samples were collected. The data presented in the tables and the discussion of the significance of the observations are based upon the more refined methods for procuring information. The range of problems discussed is most impressive. The "Hydrography of the *Ingolf* Expedition" by Knudsen is a classic contribution to oceanography. This was the accomplishment of a young man in his twenties. The *Ingolf* report was published in 1899.

Progress in many branches of science depends upon the possession of adequate instruments, a body of established physical constants and proper procedure. The mere recognition of a scientific problem will not solve that problem. Knudsen's first oceanographic experience made him keenly conscious of the fundamental needs of physical oceanography, and he set about the development of apparatus and the determination of physical constants. His invention of standard sea water and his refinements of chlorine titration for the determination of the salinity and density of sea water over the entire range of temperatures encountered in the ocean, and the tables prepared by him to embody the results of long-continued investigations, constitute a foundation stone of modern dynamical oceanography. The tools provided by Knudsen are necessary for utilizing the equations formulated and developed by V. Bjerknes, Helland Hansen, Sverdrup, Hesselberg and others for solving problems in dynamical oceanography. This statement also applies to the numerous graphical methods of treating oceanographic data.

Knudsen has made a number of designs of oceanographic apparatus, such as a frameless water-bottle, a bottom-samples for hard bottoms and a spectro-

photometer. He has also paid fruitful attention to a number of oceanographic problems. His first papers were on the influence of plankton on the quantities of oxygen and carbonic acid dissolved in sea water. His researches in the field of low pressure phenomena in gases are better known to physicists than to oceanographers.

In addition to his activities already mentioned, Knudsen has since 1902 rendered invaluable service as a consultant in hydrographical investigations for the Danish Government and the International Council for the Exploration of the Sea.

The members of the committee that nominated Professor Knudsen for the Agassiz Medal are happy that the academy approved its recommendation. Professor Knudsen richly deserves the honor conferred upon him.

T. WAYLAND VAUGHAN

WASHINGTON, D. C.

PRESENTATION OF THE MARY CLARK THOMPSON MEDAL TO AMADEUS WILLIAM GRABAU

THE Committee on the Mary Clark Thompson Fund, meeting in 1936, decided unanimously to award the medal provided for in this fund "for most important services to geology and paleontology" to Amadeus William Grabau, professor of paleontology in the National University of China and chief paleontologist to the Chinese Geological Survey. Among the recipients of this medal since 1924, chiefly paleontologists, are C. D. Walcott, E. de Margerie, J. M. Clarke, J. Perrin Smith, W. B. Scott, E. O. Ulrich, David White, F. A. Bather and, in 1934, Charles Schuchert.

The committee noted the distinguished services of Professor Grabau in general and stratigraphic geology, in the science of non-metallic mineral deposits and particularly in paleontology. His paleontological researches cover the Paleozoic of New York and during the last seventeen years the paleontology of China. The results of this work are contained in a splendid series of monographs on Chinese Paleozoic and also Mesozoic fossils, the last volume of which was published like the rest by the Academia Sinica, in Peking.

Professor Grabau was born in Wisconsin in 1870. He studied first in the Massachusetts Institute of Technology, where he served as instructor from 1892 to 1897. After obtaining his Sc.D. at Harvard in 1900 he served as adjunct professor at Columbia University, 1902–1905, then as professor from 1905 to 1919. In 1920 he was appointed to the two important positions in China mentioned in the first paragraph of this address, and he has remained there for the last seventeen years working unceasingly and most successfully on the paleontology and geology of China. His contributions are fundamental and exhaustive. And this in spite of severe physical handicaps during later years which would have discouraged any man with less courage and energy. Among his characteristics are an indomitable nature; a faculty of inspiring others with his enthusiasm; an ability to plan and carry out the work to which he has devoted his life.

The work of Professor Grabau is incorporated in a long series of publications. In 1910 he published in collaboration with another distinguished paleontologist, Professor H. W. Shimer, of the Massachusetts Institute of Technology, a widely used book on "North American Index Fossils." Later came "Succession of Faunas in the Middle Devonian in U.S.A."; the "Hamilton Fauna of Michigan"; "The Phylogeny of Invertebrates, Chiefly Gastropods"; "Principles of Stratigraphy" (second edition in 1921); "Textbook of Geology," 2 volumes, 1921; "Nonmetallic Deposits," 2 volumes, 1922; "Ordovician Fossils of North China," 1921; "Stratigraphy of China," 1925; and last but not least the succession of volumes referred to above and published by the Academia Sinica under the general heading, "Paleontologia Sinica." Besides these there are a great number of shorter papers. Enough of an accomplishment, one might say; enough to fill a long life.

I feel sure you will agree with me that in presenting this medal we are paying a just tribute to a most distinguished paleontologist and geologist who has brought honor to American geology to the four corners of the earth.

We regret deeply that Professor Grabau is unable to be here in person, but rejoice that we may entrust the medal to Mrs. Grabau, who is here with us to-night and who will transmit the token to Professor Grabau with our admiring regards.

WALDEMAR LINDGREN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ABSTRACTS OF PAPERS PRESENTED AT THE WASHINGTON MEETING OF THE NATIONAL ACADEMY OF SCIENCES

A catalogue of neurohumors: G. H. PARKER. Neurohumors are hormones produced by the secretory portions of the nervous system or by glands immediately associated with this system and serving as means of activating other parts of the nervous system and its effectors, such as muscles, glands, chromatophores and the like. Neurohumors are well illustrated by adrenalin, a secretion of the adrenal gland, and by intermedin, a product of the

intermediate lobe of the pituitary gland. Both these neurohumors act on the vertebrate melanophores of the integument, adrenalin causing these color cells to concentrate their pigment, intermedin to disperse it. In fishes such as the catfish the melanophore pigment disperses not only to intermedin, but also to a neurohumor from the melanophore nerve terminals. This pigment probably concentrates to a blood-borne neurohumor like adrenalin, perhaps adrenalin itself, and to a neurohumor from a second series of nerve terminals. Thus four sets of neurohumors are concerned with the activities of the melanophores in the catfish, two dispersing and two concentrating. Those from obvious glands are soluble in water and carried by the blood. Hence they have been termed hydrohumors. Those from the nerve terminals are insoluble in water but soluble in ether or oil, hence lipohumors. Hydrohumors are general in action, lipohumors local in action. Beside the four neurohumors acting on melanophores, there is in some fishes like the killifish an additional and independent set of neurohumors acting on the yellow cells or xanthophores. Thus in the chromatophore system there must be many kinds of neurohumors. When these many neurohumors are added to those such as acetylcholin, sympathin, and so forth, from other parts of the nervous system, it is seen that neurohumors, contrary to the older view, are an extremely diverse and numerous set of substance.

Pinocytosis—Drinking by cells: WARREN H. LEWIS. Normal macrophages and many malignant cells when cultivated outside the body thrust out thin active wavy ruffle pseudopodia which entrap and fuse around portions of the surrounding fluid and enclose them as globules within the cell. The globules move centrally, the contents are digested and the fluid then diffuses out of the cell. In the course of a few hours a cell may drink several times its volume of fluid. In this manner cells take in complex substances in solution such as proteins which can not diffuse into them. The macrophages, which come from the large mononuclear white blood cells, are scattered in the tissue spaces throughout the body in enormous numbers. We have been familiar for many years with the rôle they play as phagocytes; they ingest and digest dead cells and other debris such as occur in black and blue spots. As pinocytes (drinking cells) they probably play a still more important rôle, namely, the maintenance of the body fluids in proper condition, for there is good evidence that within the body they are continually drinking in, digesting and thus modifying the tissue fluids which bathe most of the cells of the body.

Hereditary vulnerability to dietary defects in the development of bone: G. L. STREETER, E. A. PARK and DEBORAH JACKSON. At the end of the first month, when their bone development is most active, young rats can be weaned and placed on any desired diet. After a sufficient period of test diet, if one wishes to study the effect of that diet on growth of bone, one can make x-ray films of a selected bone area and record the progress of its development. The animals in our experiments, after being subjected for three weeks to a rachitic diet and then x-rayed, were returned to a normal diet and reared, uninjured by the experience. Four months later they were bred. The breeders were chosen on the basis of the x-ray record of their sensitivity to the diet. Following fourteen generations of such selection and inbreeding, two strains of rats have been developed which in all appearances are alike, save in the one character that one of them reacts more severely to a rachitic diet (vitamin-D-free, high calcium and low phosphate) than the other strain. These experiments reveal the plastic nature of the growth line (epiphysis) of bones and its sensitivity to disturbances in the chemical composition of the body fluids. They also support those investigators who claim that heredity is a definite etiological factor in abnormal bone development, of the type seen in rickets. From such experiments we can thus understand why under equally unfavorable conditions the children in some families acquire rickets, while others do not.

The distribution of gene frequencies in populations: SEWALL WRIGHT. (To be printed in SCIENCE.)

Immunity and reinfection in experimental poliomyelitis: SIMON FLEXNER. As experience has grown, it has become apparent that the two immune states in poliomyelitis (infantile paralysis), one based on recovery from an attack of the disease and the other symptomless reaction to virus injections (vaccination), are not identical. They do agree in that under both sets of conditions antibodies usually appear in the blood; they differ in that symptomless immunization is less protective against reinoculation of the virus than is the state of resistance which develops upon a symptomatic infection. That reinfection called second attack does occur is established for children and even for monkeys, although this phenomenon has been given little attention. The study to be reported is based on a considerable number of monkeys which have recovered from attacks of poliomyelitis experimentally induced. The virus employed for reinoculation was always instilled into the nose. Several kinds of virus, derived from epidemics of infantile paralysis occurring in the years 1909 to 1935, were employed for these experiments. Attention was paid to the occurrence of distinct immunological strains among these specimens of virus used for reinfection. Certain conclusions have been reached as a result of the studies which may be stated briefly as follows: Monkeys which have recovered from an attack of experimental poliomyelitis are subject to reinfection by the nasal route. Second attacks of the disease result from inoculation with the specimen of virus used to produce the first attack and with specimens of different origin. Reinfection takes place in monkeys which have recovered from mild and from severe attacks and in convalescent animals which have been subjected to hyperimmunization. The two-year quiet period proposed by Still to separate relapses from second attacks, judging from the monkey, is probably excessive. Until greater attention is given the reinfections of varying intensities in man, conclusions on this point must be wholly tentative.

Experimental menstruation: GEORGE W. CORNER (introduced by George H. Whipple). It has long been known that menstruation is dependent upon the ovaries. Since the identification of the two ovarian hormones, oestrin

(the "female sex hormone") and progestin (the corpus luteum hormone) a number of observations have been made which hint that the menstrual phenomena may ultimately be explained in terms of the action of these two hormones upon the uterus. In a castrate monkey, for example, the cessation of a course of oestrin injections causes menstruation-like bleeding (E. Allen), and menstruation has therefore been tentatively explained as due to cyclic fluctuations in oestrin level. Oestrin (in moderate, presumably physiological dosage) does not, however, inhibit, in intact monkeys, an expected menstrual flow (Corner), but progestin does inhibit menstruation (Corner) and also oestrin-deprivation bleeding (Engle, Smith and Shelesnyak; Hisaw). Moreover, measurements of the oestrin content of the blood in women have not certainly revealed a correlation between menstrual bleeding and variations of the oestrin level (Fluhmann). In the experiments now to be reported, castrate monkeys receiving injections of oestrin (100 or 125 international units) were also given, after a suitable control period, one mg pure progesterone daily for 10 days. Menstruation-like bleeding occurred four or five days after cessation of the progesterone, in spite of the continued oestrin treatment. Elevation of the oestrin dosage to 500 international units did not completely prevent bleeding after progesterone under these conditions. Quantitative experiments designed to explain the mechanism of this effect are now in progress. The experiments point to a possible explanation of the menstrual bleeding of the uterus (in ovulatory cycles, at least) as the result of alternating presence and absence of the corpus luteum hormone, without the necessity of postulating cyclic variations in oestrin level.

Body fat as a factor in heat production: FRANCIS G. BENEDICT and ROBERT C. LEE. It has been commonly believed that body fat is metabolically inert. Experiments on geese and mice at the Nutrition Laboratory, however, indicate that body fat plays a rôle in metabolism. The geese were adults and the differences in size represented, chiefly, differences in fat content, for little protein is added to the body when adult geese are fattened. The total heat production was greater the larger the goose and in nearly direct proportion to the increase in weight. The heat production per unit of weight was essentially the same with geese weighing from 4.5 to 7.5 kg, although it has usually been found that the larger the animal species the lower is the heat production per unit of weight. Comparisons were also made of the basal metabolism and the body composition of the 20-gm albino mouse, the 60-gm fat mouse and the 8-gm dwarf mouse. Per unit of surface area the metabolism of the fat mouse is nearly twice as great as that of the dwarf mouse and 15 per cent. greater than that of the albino. Although the fat mouse weighs three times as much and has twelve times as much body fat as the albino, both have nearly the same amounts of body nitrogen. Yet the total daily heat production and the heat production per gram of dry protein of the fat mouse is more than double that of the albino. That body fat increases the energy production is, therefore, undeniable. The obese must pay in calories for their fat loads.

Sympatho-mimetic influence of deuterium oxide[1]: HENRY GRAY BARBOUR (introduced by Yandell Henderson). The mammalian body is over two thirds water. Substitution of one half the water by the recently discovered heavy water (deuterium oxide) is incompatible with life. When, however, the body water is but one fifth saturated with heavy water a mouse survives, but lives at a faster rate; that is, metabolism is increased by some 20 per cent. or more, usually with some elevation in body temperature. These effects appear due to excessive stimulation of sympathetic nerve mechanisms (sympatho-mimetic action). More definitely, sympathetic stimulation by heavy water can be shown in the pilomotor (hair raising) and exophthalmic (pop-eye) mechanisms of mice. When one fifth saturated they not only become rough-furred and pop-eyed, but these effects can be abolished almost immediately by ergotoxine, an alkaloid specifically depressant to the sympathetic system. Fish resort to protective camouflage in light surroundings by turning themselves pale. This is done by the sympatho-mimetic effect of light acting through the eye to cause contraction of the dark pigment in the melanophores. Heavy water also contracts melanophores but not after ergotoxine. One can mimic all the above effects, on metabolism, temperature, fur, eyes and skin, by injecting epinephrine, one of the sympatho-mimetic emergency hormones, secreted by the adrenal glands to prepare the body for fight or flight. Heavy water reinforces the natural substance epinephrine. Possibly it exhibits its sympatho-mimetic influence by delaying the disappearance of the natural hormone from the body. The details are described elsewhere in respective co-authorship with Drs. Bogdanovitch and Herrmann and Misses Trace and Rice.

The effects of alcohol as influenced by blood sugar: HOWARD W. HAGGARD and LEON A. GREENBERG. (To be printed in SCIENCE.)

Embryonic induction in regenerating tissue: OSCAR E. SCHOTTÉ (introduced by Ross G. Harrison). Previous experiments presented at last year's meeting of the Zoologists at Atlantic City have shown that the mesenchyme of regenerating extremities of Amphibia is totipotent, since typical lenses have been obtained by transplantation of this tissue on eyes of adults previously deprived of their lenses. In order to further test the potencies of this mesenchyme, embryonic eye-cups of *Rana pipiens* (stage 28 or 29, Harrison) have been transplanted below the skin of regenerating tails of large tadpoles. These eye-cups not only induced the regenerating mesenchyme to differentiate into typical lenses, but also induced in every case a complete redifferentiation of the surrounding cells. The loose mesenchyme now becomes a dense mass of cells, numerous mitotic figures occur, and eventually the differentiation of organs not connected with eyes can be observed: olfactory capsules, ear vesicles and even mouth cavities appear in the midst of the tadpole tail. This unusual effect of typical embryonic inductors is tentatively explained by the spreading of correlated morphogenetic fields, a process quite different from that

[1] These investigations are supported by the research funds of the Yale University School of Medicine.

which occurs in normal development. In the embryo, a spatially closed system, the differentiation of the available materials blocks any further action of "organizers," for which only a limited amount of cell material is available. In this new process of induction in regenerates, on the contrary, far more generalized effects are obtained because proliferation secures a continuous supply of fresh, undifferentiated cells. After the cells in the midst of which the inductor has been implanted become differentiated into new organs, they in turn serve as inductors to the proliferating mesenchyme. Other facts have shown that morphogenetic fields continue to be active throughout life, and now the above experiments suggest that proliferating mesenchyme embodies properties of indifferentiation similar to those of the embryonic ectoderm of amphibians before gastrulation.

On the evaporation from the oceans: H. U. SVERDRUP (introduced by T. Wayland Vaughan). The water which evaporates from the oceans is equal to the amount of water vapor which is transported upwards from the sea surface by processes of molecular diffusion and by eddy conductivity. Turbulence research in laboratories has led to a semi-theoretical expression for the eddy conductivity of air flowing over a rough surface and to a simple law for the variation of velocity with increasing distance from the surface. Observations of wind velocity at various levels have shown that this law is qualitatively valid over the sea. The same law is valid when dealing with the humidity, except that then it is necessary to assume the existence of a thin layer near the surface through which transport of water vapor takes place by diffusion. The thickness of this layer was found to be inversely proportional to the wind velocity, decreasing from 0.75 cm at a wind velocity of 1 m per second to 0.075 cm at a wind velocity of 10 m per second. Supposing that above this layer the eddy conductivity has the value which follows from the laboratory experiments and that the numerical constants which have been determined by such experiments can be applied, the amount of water vapor which is transported upwards can be computed if the wind velocity, temperature and humidity are known at one level and if the surface temperature of the water has been observed. From the Atlantic Ocean average meteorological data and corresponding average values of the evaporation are available. The values of the evaporation which have been computed by means of the meteorological data, making use of the above-mentioned assumptions, agree very well with the observed values. It seems, therefore, possible that by means of this procedure the evaporation can be computed under any given meteorological conditions.

How deep do ocean currents flow: COLUMBUS ISELIN (introduced by Henry B. Bigelow). At the present time physical oceanographers are in sharp disagreement as to what depths should be assigned to the lower boundaries of the major ocean currents. The older point of view is that while velocity decreases gradually with depth, some flow parallels the surface movements down to at least 2,000 meters. The newer conflicting theory is that the layer having a minimum oxygen content is also nearly motionless, and for all practical purposes marks the lower limit of the surface currents. Since the axis of the layer having the least oxygen is found at depths of only 300 to 400 meters near the equator and nowhere is deeper than 900 meters, all attempts to calculate the volume or velocity of ocean currents give very different results, depending on which of the above theories the particular investigator favors. Unfortunately as yet little conclusive evidence is available to support either view. The significance of this controversy in the case of the Gulf Stream and the Northern Equatorial Current is described and several arguments advanced that indicate that the older idea of relatively deep ocean currents should by no means be thrown into the discard.

Plankton and radiolarian ooze in Paleozoic formations of New York: RUDOLF RUEDEMANN. The plankton consists principally of the graptolites and associated organisms that were connected with the Sargasso-seas of the Atlantic Ocean and were carried into the great Appalachian geosyncline that extended from Newfoundland to beyond Alabama, at such times when it was open to the ocean currents. The associated organisms are principally small sponges, very primitive brachiopods and crustaceans. Other planktonic organisms of later Ordovician, Silurian and Devonian periods will also be shown. The Radiolarian faunas have been discovered in thick chert beds, associated with the graptolite shales. Nearly all the chert beds contain radiolarians and nothing else save occasional sponge spicules and graptolites. Some beds are entirely composed of radiolarians and these are compared to the "radiolarite" of the Alps and East Indies, which is considered as fossilized "radiolarian ooze." The fauna consists almost entirely of genera still living to-day and some of them are not found above 12,000 feet in the present oceans. The conclusion is therefore reached that the radiolarian chert represents radiolarian ooze formed at a depth corresponding to that at which the ooze is formed to-day and that the bottom of the Appalachian geosyncline sank at times to such abyssal depths.

Random Waring's theorems: NORBERT WIENER and NORMAN LEVINSON. It is well known and has been proved by Hilbert that every number is the sum of at most a finite number of kth powers of integers. There is reason to suspect that the vital part of this theorem concerns not the number-theoretic nature of the terms n^k but their manner of growth. The present paper is devoted to the proof that if λ_n is chosen at random between zero and n^k, in almost every case almost every integer can be represented as the sum of $k+1$ such numbers, and in almost every case there will exist a set of integers of density greater than zero which need $k+1$ such numbers for their representation. Similar theorems are proved for random selections not among all integers of a given range but among all integers of certain specified sets lying in a given range.

Trihornometry: A new chapter in geometry: EDWARD KASNER. A trihorn is defined as the combination of three curves C_1, C_2, C_3 passing through a common point in a common direction. The three horn angles are C_1C_2, C_2C_3,

C_3C_1. The three curves are represented by three points P_1, P_2, P_3 in an auxiliary plane; thus the trihorn is represented by a triangle. The conformal invariants then correspond to the three sides M_{ij}, and the three angles σ_{ij} of the triangle in a new metric where distance is defined by $(x_2-x_1)^2/(y_2-y_1)$. Neither equilateral nor equiangular triangles exist in the new geometry. The sides obey a certain inequality, and the angles a certain equality. If two sides are equal, the opposite angles are never equal; but the sum of the opposite angles is unity. In general any three of the six parts of a triangle (except the three angles) determine the other three, but sometimes two distinct solutions exist. Two triangles with sides respectively equal are not necessarily congruent. A full set of formulas of trihornometry is found. The medians are concurrent, but not the altitudes.

Lower reducibility of functions: MARSTON MORSE. Many of the most important problems of modern analysis and mathematical physics are concerned with the existence of unstable equilibria. Stable equilibria are frequently associated with minima, and the classical variational theory is relatively complete for such cases. For unstable equilibria no adequate general existence theory has been developed. A periodic orbit corresponding to the moon has, for example, never been proved to exist rigorously, and it has been shown that if it does exist it affords no minimum to the Jacobi least action integral and is in that sense unstable. The methods of the author when finally developed would appear adequate for solving such problems. The classical condition of lower semi-continuity which with compactness is adequate for proving the existence of minima is not sufficient for establishing the existence of extremals not affording minima. A new condition of *lower reducibility* has been discovered by the author. Roughly stated, it requires the existence of a deformation of the space neighboring a given point p such that the points at which the functional F exceeds $F(p)$ shall be deformed so as to uniformly decrease F. Such a deformation is shown to exist in all ordinary problems, and various important applications have been made.

Electrokinetics XIX. Interfacial energy and molecular structure of organic compounds V. The electric moment of an Al_2O_3: benzene-nitrobenzene interface: ROSS AIKEN GORTNER and HENRY B. BULL. The electric moment of the double layer at the interface between Al_2O_3 and pure benzene, pure nitrobenzene and mixtures of these liquids was studied by streaming potential techniques. A zero electric moment was for the interface in pure benzene, but a very high value was obtained in pure nitrobenzene. In mixtures containing 10 mol per cent. of nitrobenzene the electric moment was inappreciable and a very low value was obtained for mixtures containing 25 mol per cent. nitrobenzene. Only when the nitrobenzene exceeded 50 mol per cent. were high electric moments obtained. The data are tentatively interpreted as indicating the existence in the mixture of a bimolar compound of benzene-nitrobenzene which prevents the polar character of the nitrobenzene from markedly influencing the electric moment. This hypothesis is supported by the fact that benzene-nitrobenzene forms a eutectic mixture at 51 mol per cent. of nitrobenzene.

Mechanism of the reaction of substitution and Walden inversion: P. A. LEVENE and ALEXANDRE ROTHEN. In order to test recently advanced theories of the mechanism of the reaction of substitution claiming that every substitution by a negative atom or group takes place on the positive end of a dipole, experiments were instituted based on the following considerations. If a single reaction of substitution on an optically active carbon atom should lead to inversion of configuration, then two consecutive reactions of substitution should lead to a substance having the configuration of the starting substance. On the basis of the postulate that the substitution of a $-N_3$ group, a pseudo halogen, proceeds similarly to that of a halogen atom, it was possible to show that in the set of reactions

$$R\text{—}OH \xrightarrow{HI} RI \rightarrow RN_3 \rightarrow RNH_2 \quad \left(R = H\text{—}\overset{R_1}{\underset{R_2}{C}}\text{—}\right),$$

where R_1 and R_2 stand for normal alkyl groups), the configuration of the amine being similar to that of the carbinol, each of the two reactions of substitution is connected with an inversion of configuration. However, when R_1 is an unsaturated radicle, or a phenyl group, C_6H_5, the two consecutive reactions of substitution may lead to a substance having a configuration opposite to that of the starting material, thus showing that only one substitution is accompanied with inversion of configuration, the other proceeding without inversion. Hence, one substitution by a negative ion takes place on the positive, the other on the negative end of the dipole.

The romance of hemoglobin: G. H. WHIPPLE.

On the temperature coefficients of the four transverse magnetic effects in copper: EDWIN H. HALL. The method of experimentation is shown. The investigation, which is not yet ended, indicates that, with a rise of temperature from 25° C. to 85° C., the Hall effect changes less than one per cent., the Ettingshausen effect increases many per cent., the Leduc effect decreases many per cent. and the Nernst effect decreases less, perhaps 7 per cent.

Internuclear distance in oxygen molecules: HAROLD D. BABCOCK. A clearer view of the structure and properties of molecules is the aim of many investigations. The spectroscopic method is particularly useful for molecules consisting of two atoms, among which oxygen affords a favorable case and at the same time has fundamental interest for chemists, physicists and biologists. The theory of molecular spectra has shown that the positions of the spectral lines of a gas may be utilized to determine some of the mechanical properties of the molecule. For example, the distance separating the atoms in the oxygen molecule may be found from measurements of atmospheric oxygen. Recent data give this distance with greatly increased accuracy. Although its value is only about a hundredth of a millionth of a centimeter, variations of the order of a millionth of a millionth of a centimeter are appreciable. The measurements indicate a possible contraction of 2 parts in 10,000 when one of the atoms in the ordinary molecule $O^{16}O^{16}$ is replaced by the rarer heavy oxygen atom of mass 18.

The structure of Langmuir-Blodgett films of stearic acid: L. H. GERMER and K. H. STORKS (introduced by Frank B. Jewett). We have prepared multiple molecular layers of stearic acid upon metal blocks by the method developed by Dr. Katharine Blodgett (*Jour. Amer. Chem. Soc.*, 57: 1007, 1935). Electrons scattered from such built-up surface films produce diffraction patterns consisting of segments of sharp lines lying normal to the specimen surface and arranged along diffuse inclined bands which are parallel and equally spaced. The following conclusions can be drawn from these patterns: (1) The stearic acid is formed into large crystals belonging to the monoclinic system. (2) These are oriented upon the surface with a long crystallographic axis parallel to the long axes of the individual molecules and inclined by 57° to the surface plane, and with two orthogonal axes of lengths 9.4A and 5.0A lying in the surface plane. (3) The crystals possess symmetry characterized by a mirror glide plane normal to the shorter of these axes. This structure is in precise agreement with that of single crystals of stearic acid which we have recently investigated. In these single crystal studies we have discovered different polymorphic modifications. The Langmuir-Blodgett films which we have produced are identical with the modification which we have studied in greatest detail. In our earlier work on these films (*Phys. Rev.*, 50, 676, 1936) we were unable to determine the structure. This work was carried out upon films which had been stripped from the plate upon which they were formed. We now believe that this mechanical treatment produced severe strains and materially changed the molecular arrangement.

The influence of the earth's magnetic field on cosmic ray intensities up to the top of the atmosphere: I. S. BOWEN, R. A. MILLIKAN and H. V. NEHER. Measurement on cosmic-ray intensities such as those made in July, 1936, at San Antonio, Texas, and already published (*Phys. Rev.*, 50: 992–998, 1936), have now been made with equal accuracy in Madras, India. A comparison of the two resulting curves and that earlier obtained in the Fordney-Settle flight makes it possible for the first time to determine experimentally the complete law of absorption of electrons going through the atmosphere in two different ranges of energy, namely, from 2.5×10^8 M E V to 6×10^8 M E V, and from 6×10^8 M E V to 17×10^8 M E V. A law not greatly different from the Bethe-Heitler law as extended by Carlson and Oppenheimer (*Phys. Rev.*, 51: 220, 1937) is found to reproduce reasonably well observed findings.

Cosmic rays and the magnetic moment of the sun: M. S. VALLARTA (introduced by Arthur H. Compton). The indication by Cosyn's stratosphere measurements that the threshold of the latitude effect begins at about 49 degrees for all altitudes may be explained either by (1) assuming that the primary rays have a sharp threshold energy or (2) that particles of smaller energy are prevented from reaching the earth by the action of the magnetic field of the sun. Consequences of the latter hypothesis (suggested originally by Janossy) include diurnal and annual variations in intensity whose agreement with observation is questionable. Any effect due to a possible magnetization of the moon is ruled out because the periodic fluctuations would be greater than is shown by observation.

The structural forces of atomic nuclei: M. A. TUVE, L. R. HAFSTAD and N. P. HEYDENBURG (introduced by W. W. Coblentz). Measurements on the angular scattering of a beam of protons passing through hydrogen gas have resulted in the direct observation and quantitative measurement of attractive forces between two protons when they are brought within nuclear distances of each other, and demonstrate the failure of the Coulomb law of repulsion at very close distances. The measurements show that the proton-proton forces are nearly identical with the proton-neutron and neutron-neutron forces; these three attractive forces are the structural basis for the formation of the nuclei of all the chemical elements. Our observations of proton-scattering in the region 600 to 900 kilovolts gave a quantitative specification of the nuclear forces, as worked out on the basis of the quantum mechanics by Breit, Condon and Present. Observations in the region 200 to 500 kilovolts confirm the results obtained at higher energies and give a very direct demonstration of the fact that the forces between two protons change from repulsion to attraction as they are brought closer together.

Terrestrial effects accompanying several bright chromospheric eruptions: A. G. MCNISH (introduced by F. E. Wright). The recent observation that the intense bright-hydrogen eruptions in the chromosphere on April 8, August 25 and November 6, 1936, were accompanied by simultaneous effects on the earth's magnetism and on radio communication promises a basic advance in the study of the earth's outer atmosphere. Immediately when these bright eruptions were observed with the spectrohelioscope radio signals normally reflected from the *E*-layer and higher layers of the ionosphere ceased to be returned, and a special type of change occurred in the earth's magnetic field. The radio effects indicate that a great increase of ion-density occurred at heights between 60 and 90 km (below the *E*-layer). On the basis of the Stewart-Schuster theory the magnetic effects would be attributable to an increase in electric currents ordinarily flowing in the ionosphere. The beginning of fade-out and magnetic change occurred simultaneously with arrival of visible light from the eruptions. These effects were observed only on the lighted hemisphere of the earth. Thus it is indicated that the ionizing agent was light radiation and not corpuscular radiation. These mutually consistent terrestrial effects may be explained on the assumptions (1) that excitation of gases in the solar atmosphere gave rise to bright-line emission in the ultra-violet region as well as the visible region and (2) that such bright-line emission was much more intense than the ionizing radiation usually coming from the sun. This bright-line emission enhanced ionization, therefore conductivity, below the *E*-layer, where rapid recombination or limitation by absorption prevents high ion-density from normal ultra-violet light. The improved conductivity increased the currents responsible for diurnal variations of the earth's

magnetism and thus caused the unique changes observed. The observed fade-outs of radio signals may be explained by absorption in this region because of high frequency of molecular collisions at these low heights.

Million-volt direct-current x-ray generator for the Huntington Memorial Hospital: J. G. TRUMP and R. J. VAN DE GRAAFF (introduced by Karl T. Compton). This paper describes a 1,000-kv x-ray generator developed by the Massachusetts Institute of Technology and recently installed at the Huntington Memorial Hospital in Boston for the treatment of cancer. The high-voltage source is an electrostatic generator employing six belts, each three feet wide, of commercial belting material and running at about 5,000 feet per minute. The generator operates normally at a steady d–c potential of 1,000-kv with 3 milliamperes on the target, but it can be used over the full range from 400 kv to 1,200 kv. The x-ray tube is continuously evacuated and is of the cascade type, having twenty sections mounted vertically, the potential distribution along the tube being controlled by corona. A lead-shielded steel tube carrying the target at its lower end continues downward from the high-voltage tube well into the treatment room below. This arrangement leaves the treatment room free from all electrical apparatus and high-voltage hazard and permits a wide range of treatment distances. The electron beam is accurately focused on the water-cooled lead target, which is at ground potential, and the radiation transmitted in the downward direction is utilized in treatment. The generator produces an intensity of 100 roentgens a minute at 80 centimeters' distance with 4 millimeters' lead filtration. It is compact, rugged and simple in operation.

Unique crystallization phenomena of protocatechuic acid; motion pictures of automotive crystals: R. W. WOOD. Perhaps the most remarkable phenomenon of crystallization: discovered in 1888 by Otto Lehman and apparently completely lost sight of. The substance crystallizes in four different modifications according to the conditions. The one of especial interest develops branched rods like the claws of a crustacean. The joints straighten out by a progressive motion of the sharp angle of bend (twin-plane), which in one or two seconds runs along the crystal to the tip, the bent rod becoming straight. Thicker rods frequently grow a cluster of spreading claws at the end, which suddenly close together and unite into a single crystal which forms a prolongation of the rod. Large clusters of these crystals form resembling the tentacles of a barnacle, and there is constant movement as the bent rods straighten out and the finger-like tips come together and fuse. Under other conditions long, straight needles form, or rhombs resembling Iceland spar.

The measurement of light signals on moving bodies by transported rods and clocks: HERBERT E. IVES. The equations are developed for describing the times of transit, distances traversed and velocities of light signals on moving bodies, with no restriction on the speeds with which the measuring rods and clocks are moved. The study is based on the assumptions of Fitzgerald, Lorentz and Larmor: (1) That moving rods are contracted in the direction of motion in the ratio

$$\sqrt{1-\frac{v^2}{c^2}}:1$$

where v is the velocity of the rod, and c the velocity of light; (2) that the frequencies of moving clocks are reduced in the ratio

$$\sqrt{1-\frac{v^2}{c^2}}:1.$$

The expressions derived are put in terms of the relative velocities of the rods, clocks and bodies concerned, as observed. These expressions are invariant with v, as long as identical measuring procedures are used, *i.e.*, the rods and clocks are moved with the same observed velocities. The velocity of light on a moving body, so measured, is not the constant c, but the product of c and a function of the velocities of transport of the rods and clocks. This function approaches unity as the rod and clock velocities become small. The time of transit of a light signal to a distant mirror on a moving body, so measured, is not half the total to and fro time, but approaches this as rod and clock velocities become small. The entire set of formulae approximate the Lorentz transformations as the observed rod and clock velocities become small with respect to the velocity of light.

Differences in mutability in various wild-type lines of Drosophila melanogaster: M. DEMEREC (introduced by A. F. Blakeslee). Mutability of the following wild-type lines was studied by determining the frequency of the occurrence of spontaneous X-chromosome lethals: Florida-inbred; Wooster, Ohio; Formosa, Japan; Oregon-R; Swedish-b; California-C; Huntsville, Texas; Urbana, Ill.; Canton, Ohio; Amherst, Mass.; Woodbury, N. J.; Tuscaloosa, Ala.; Lausanne; Seto, Japan; and Kyoto, Japan. Of these, the first three mentioned had a higher rate of mutability than the other lines. The mutability of the Florida line was 1.09 per cent.; of the Wooster, Ohio, 0.63 per cent.; and of the Formosa line 0.39 per cent., while the average rate for the other 13 lines was only 0.1 per cent. The responsibility for the high mutability rate of the Florida stock was traced to a recessive factor located in the second chromosome. Evidence suggests that this gene is specific in its action: that it increases the mutability rate only in early embryonic development and only in germinal tissues. Such genetic factors influencing the stability of a genom play an important rôle in increasing the variability of the line where present, and thus they may have important bearing on the evolutionary processes within a species.

Bud sports in Datura due to elimination of specific chromosomes: ALBERT F. BLAKESLEE, AMOS G. AVERY and A. DOROTHY BERGNER. In Datura clear-cut cases of bud sports due to mutations in single genes have not been identified. Bud sports due to chromosomal mutations, however, have been relatively common. Those most frequent involve doubling of the whole chromosomal complement to produce a diploid branch on a haploid or a tetraploid branch on a diploid. Elimination of a single chromosome or a chromosome fragment is a not uncommon cause of bud sports. A tabulation of the records for the last 15 years since chromosomal eliminations were first noted shows that such chromosomal deficiencies are con-

ned almost entirely to those which involve the 1·2 or the 17·18 chromosome. The condition is most striking in respect to the 1·2 chromosome. Nearly every season at least a single case is found in which the 1·2 chromosome is eliminated to form a 2n − 1·2 branch. The ·1 half of this chromosome seems to be chiefly responsible for the chromosomal elimination. In several cases a 2n + 1·18 plant has produced a 2n branch by the elimination of the 1·18 chromosome, while no 2n + 2·17 plants have shown sectorial deficiencies. The 1·1 chromosome in the secondary 2n + 1·1 type is so frequently eliminated to produce 2n branches that we have found it difficult to keep this type growing without its reverting to normal diploid. The complementary 2n + 2·2 secondary, of which larger numbers have been under observation, has only once been observed to have eliminated its 2·2 chromosome. It is concluded that the rate of chromosomal elimination in the formation of bud sports is different for different chromosomes and that, in the case of the 1·2 chromosome, it is the ·1 half which most strongly stimulates the elimination.

A treatment of hosts having opposite effects on leukemic cells of high and low virulence: E. C. MACDOWELL, J. S. POTTER and M. J. TAYLOR (introduced by A. F. Blakeslee). A single treatment of susceptible hosts with embryo tissue of specified genetic constitution will induce resistance to implanted leukemic cells that have become highly virulent in the course of long-continued transfer from mouse to mouse. These hosts are under two months old; if mice of this strain are not treated in any way, nine out of ten will develop leukemic cells spontaneously in later life. However, the identical embryo-treatment, continued at monthly intervals throughout life, completely fails to reduce the incidence of spontaneous leukemia: indeed, the embryo-treatment actually hastens the time of death from leukemia. Failure to induce resistance against spontaneous cancer has led to the general belief that it is not possible to immunize an animal against its own cells. But is this result due to the unique relationship between malignant cells and the animal in which they originate or to the properties of the "spontaneous" cells? This question is answered by breaking the correlation between the animal and its own leukemic cells by means of a single transfer to other hosts. Leukemic cells from a spontaneous case were inoculated into equal numbers of embryo-treated and untreated hosts. Leukemic cells from a long series of transfers (653) were used in the controls. All the controls without embryo-treatment (6) died in 6 days; with embryo-treatment, nine out of ten are alive at 3 months. The "spontaneous" cells in untreated hosts killed in 41 days (average); in embryo-treated hosts, in 32 days. Twenty-one days after inoculation with "spontaneous" cells, 16 of the 20 embryo-treated mice showed large spleens, against 4 out of the 20 mice without embryo-treatment; nine of the embryo-treated mice died before the first of the mice without treatment. Compared with long-transferred cells in untreated hosts, the "spontaneous" cells required nearly seven times as long to kill, although given in doses approximately 80 times as large. The condition in hosts induced by treatment with embryo tissue may at the same time resist the growth of highly virulent, long-transferred cells and facilitate the growth of leukemic cells taken directly from a spontaneous case. The failure of embryo treatment to resist the spontaneous occurrence of leukemia is related to the properties of "spontaneous" cells rather than to the unique relationship between an animal and its own cells.

A developmental analysis of the relation between cell size and fruit size in the Cucurbitaceae: EDMUND W. SINNOTT. The growth of the fruit from ovary primordium to maturity, in this family, is due to an increase in both the number and the size of its constituent cells. Cell multiplication occurs primarily in the early stages, and in tissues other than the epidermis it is finished by anthesis or shortly afterward. During this time cells increase somewhat in size. The bulk of the increase, however (which is often more than 1,000 fold), occurs after the last division and is responsible for most of the increase in fruit size between flowering and maturity. Different tissues behave differently, the inner ones attaining a greater cell size than those toward the periphery. The developmental history also differs between genera and to a less extent between races of the same species. In *Lagenaria* all pericarp tissues (except the epidermis) stop dividing at about the same cell size, but this is reached first in the inner tissues and later in the outer ones. In *Cucurbita,* however, division stops at about the same time in all, and the relative cell-size differences attained at that time persist to maturity. The point at which cell division ceases, and the extent of cell enlargement, differ markedly in fruits which grow to different sizes. Both cell number and cell size are therefore important factors in determining differences in mature fruit size. Any consideration of the relation between cell size and organ size must evidently take into account these differences between tissues and between genetically diverse races.

Cerebral processes during sleep as studied by human brain potentials: E. NEWTON HARVEY, ALFRED L. LOOMIS and GARRET A. HOBART, III. A long series of records has demonstrated that the electrical potentials of the brain recorded from similar positions on the scalp of normal persons differ greatly in pattern. Two types of individuals with every possible intergrade can be distinguished; at one extreme the type with almost continuous pure alpha (ten a second) rhythm; at the other the type with practically no alpha rhythm but with marked beta (30 to 40 per second) potentials. The potential patterns during sleep are so characteristic that they may be used as a criterion of states or depth of sleep. In a person showing marked alpha rhythm the changes are: (1) More and more marked interruption of the alpha rhythm, (2) complete disappearance of the alpha activity, (3) large random potentials and (4) random potentials plus short bursts of 14 per second rhythm ("spindles"). Disturbance, such as a low sound, during (1) results in the appearance of almost continuous alpha rhythm. Disturbance during (2) and (3) results in bursts of alpha rhythm lasting a few seconds. Disturbance during (4) does not change the record. Return of alpha rhythm is sudden on awakening. The effect was

clearly apparent in one subject who unintentionally fell asleep while trying to carry out a set of instructions, namely, open the eyes during a tone and light signal, and then close them again. The tone and light lasted 5 seconds and was repeated automatically every 30 seconds. The psychological background must be kept in mind in this case, namely, a very sleepy yet conscientious person trying to obey instructions. The record showed that when the eyes were opened the alpha rhythm stopped, and when closed the alpha rhythm continued. This is the normal response of a person awake. The alpha rhythm then disappeared for periods of 20 to 30 seconds and reappeared again even when the light was on. This corresponds to the borderland of sleep when a person can sometimes signal that he is awake and sometimes not. It was quickly followed by a complete change in the record in that the alpha rhythm was replaced by random potentials which were interrupted by a burst of alpha potentials beginning .75 second after the tone appeared and lasting 2 to 3 seconds, and another similar burst after the tone stopped. This continued for five minutes and then only random potentials occurred with no alpha rhythm at the beginning or end of tone signal. Another state of sleep had been reached. Soon the 14 a second "spindles" appeared, indicating deep sleep. Shortly afterward a door was slammed, when the continuous alpha rhythm appeared and the subject awoke. During the third state of sleep when the tone signal gave rise to a short burst of alpha rhythm the subject anticipated the tone by 2.5 seconds for three successive half-minute periods. Evidently a subconscious cyclic process of some sort is going on in the brain which is no doubt the basis of our perception of time intervals. Persons with no alpha rhythm show 14 a second "spindles," but otherwise the record looks much the same whether asleep or awake. Our experience with many subjects has trained us to distinguish states of sleep with ease in the type whose alpha rhythm is marked.

Elimination of radium impurities from the blood stream: ROBLEY D. EVANS (introduced by K. T. Compton). In cases of chronic radium poisoning several micrograms of radium element are stored in the bones of the body. The usual metabolic exchange of calcium and other elements between the bones and the blood stream includes the removal to the blood stream of a small fraction of the radium stored in the bones. By increasing some ten thousand fold the sensitivity of the detection apparatus previously used in our studies of the radium eliminated daily in the body wastes, we are able to determine the radium content of 5 cc specimens of blood. Combination of these two experimental results yields information on the efficiency of the eliminative organs in removing heavy element impurities from the blood stream. In human beings the daily elimination, in the case of radium, is the order of ten times the total amount of radium impurity contained in the blood stream at any one time. With appropriate changes in radioactive detection technique, these same principles may be employed in studies of the rate of transfer from the blood stream to the intestine of a number of chemical elements, through the use of their artificially radioactive isotopes as chemical indicators.

Changes in respiratory pattern associated with different types of vocalization: WALTER R. MILES. Human subjects when connected to a closed-circuit respiration spirometer system by means of a helmet fitted with a flexible rubber collar which lightly but with air-tight closure encircles the neck can read aloud, talk, sing or engage in other types of vocalization without experiencing any uncomfortable restraint from the apparatus. Graphic tracings of respiration curves recorded under these conditions show characteristic differences according to the type of vocalization. For example, in oral reading the respiration rate is about half as fast as in silent resting (reclining posture in both); the amplitude is approximately twice as deep, the inspiration phase is quicker, and shallow "supplementary" breaths are interspersed at irregular intervals between the deeper inspirations. There is frequently a very conspicuous change in the level of breathing accompanying vocalization. The average expiration level, known to be usually quite stable, falls in singing below that for normal resting. In contrast, oral reading, conversation and, still more strikingly, impromptu speaking, all tend to show a marked increase in the reserve air amounting frequently to as much or more than the value of the tidal air in the same person. After vocalization has ended there is usually a prompt readjustment in the reserve-air volume to the former silent resting level. Psychological factors observed during the study, such as degree of tension and the manner of adjustment, appear to correlate with some of the respiratory changes observed.

Individual differences in communities: EDWARD L. THORNDIKE. Measurements were obtained of 117 cities in over a hundred characteristics, including such as infant death-rate, salaries for teachers, percentage of families paying less than $10 a month rent, percentage of houses with gas, electricity and telephone, and park acreage per person. From the city's scores in twenty-three characteristics where a high score is admittedly an indication of the goodness of life for good people, a score (call it G. G.) for general "goodness" was computed. Cities differ widely in G. G. Their differences in general "goodness" were studied in relation to per capita taxable wealth, to per capita private income and to personal qualities and behavior of the population, such, for example, as are evidenced by owning homes, having children graduate from high school, containing many physicians, nurses and teachers and few male domestic servants. It was found that only 33 per cent. of the variation of cities in G. G. was accounted for by wealth and income, and 60 per cent. by the personal qualities and behavior of its population.

Observations and measurements on the members of the National Academy of Sciences: ALEŠ HRDLIČKA. (Read by title.)

Biographical Memoir of George Davidson: CHARLES B. DAVENPORT. (Read by title.)

Biographical Memoir of Augustus Trowbridge: KARL T. COMPTON. (Read by title.)

Biographical Memoir of George Sumner Huntington: LEŠ HRDLIČKA. (Read by title.)

Biographical Memoir of Charles Edward St. John: ALTER S. ADAMS. (Read by title.)

Biographical Memoir of Carl H. Eigenmann: LEONHARD STEJNEGER. (Read by title.)

Biographical Memoir of Arthur Gordon Webster: JOSEPH S. AMES. (Read by title.)

OBITUARY

WILLIAM TEMPLE HORNADAY

OVER a span of sixty-six years—or from that day 1871, when, as a boy of seventeen, he commenced e study of the art of taxidermy at the Iowa State ollege until he wrote his last article on wild life nservation within a few weeks of his death on March —Dr. Hornaday was an ardent and creative force in e field of zoology. The term zoology is used in its oadest sense, since even this brief outline of his life ill indicate the many and varied accomplishments hich stand as an abiding monument to his creative ture, well-informed mind and impelling sympathy d interest in animal life.

The facilities at the State College soon proved too nited for him, as by this time he was committed to ology as a life-career, so he summarily left college ithout graduating and came East to study at Ward's atural Science Establishment in Rochester, N. Y. ere he rapidly perfected himself in all the branches taxidermy, and in 1874, when only twenty years age, he was sent out on his first scientific expedition d within six years his field work had taken him to lorida, Cuba and the West Indies, then to South merica, and finally to the Orient—India, Ceylon, the alay Peninsula and Borneo—from whence in 1880 e returned to the United States with a zoological useum collection said to have been the richest and ost varied ever made in the field by one man up to at time.

In that year he formed the National Society for axidermists and two years later was called to the osition of chief taxidermist of the United States ational Museum of Washington. He pursued his ork there until 1888, and during this time was re-ested by the government to conduct an expedition Montana to obtain specimens of the fast vanishing merican bison for mounting and exhibition in the useum. He completed this work with distinct origi-ality, for the method he created in mounting and rranging this group marked the beginning of the ow popular museum habitat groups.

During this same period he conceived the idea of he establishment of a National Zoological Park in the ation's capital and brought his plans to reality. Con-ress appropriated the sum of $292,000 to carry out he project, and Dr. Hornaday was made the superin-endent of the new park, which was placed under the control of the Smithsonian Institution. As a consequence of questions of policies which arose with which Dr. Hornaday was not in sympathy, he resigned and at the same time gave up his position in the United States National Museum.

For several years thereafter Dr. Hornaday lived in Buffalo, N. Y., but in 1895, upon the formation of the New York Zoological Society, he was called as director of the Zoological Park—for which plans were then being formulated. No better man could have been selected, for, in the development and carrying out of these plans, which were to place the New York Zoological Park in a premier position among such institutions anywhere in the world, Dr. Hornaday played an energetic and leading part, and it was because of his expert knowledge and creative ability in this position that he soon became known both throughout this country and abroad.

In addition to his primary interest in living animals he realized the permanent advantage which would result from the establishment of a national collection of heads and horns. He consequently formulated plans for this project and obtained enthusiastic endorsement from the officers of the society and a number of sportsmen who were the owners of trophies. Thus were laid the foundations for a national collection which eventually grew to such proportions that a building, the only one of its kind, was erected in the Zoological Park especially to house it, dedicated to the vanishing big game of the world.

His courage and independence of thought were outstanding characteristics, as well as his ability to do more than one thing well at the same time. It was during the early years of his position in New York, even when his duties as director of the park were most onerous, that he—enthusiastically supported by some of the officers of the society, such as the late Professor Henry Fairfield Osborn, Mr. Madison Grant and others—began his active work for the conservation of wild life, which engaged his vital interest up to the very last days of his life. He fought successfully for such measures as the Bayne Law to prohibit the selling of native game; the insertion into the tariff law of the provision against the importation of wild birds' plumage for millinery purposes; the promotion of the international migratory bird treaty between the United States and Canada; the Snow Creek Game pre-

serve in Montana, and the establishment of the Montana and Wichita National Bison Ranges.

Dr. Hornaday's foresight in realizing that wild-life protection work should be placed upon a permanent basis moved him to establish the Permanent Wild Life Protection Fund and with this end in view he raised, by his personal solicitation, an endowment fund, which to-day stands at a figure in excess of $100,000.

His fearlessness and the vigor of his attack frequently made him enemies. The writer of this inadequate appreciation vividly recalls the biting comments of a native Wyoming hunter, who—one night around a campfire—objected with strong expletives to "that man Hornaday in New York, who thinks he can tell us Wyoming people what we ought to do with our game." But Dr. Hornaday's courage and sincerity were potent factors in arousing public opinion. His written words had often the sting of a rapier thrust. He was an unrelenting adversary and it is due to him as much as to any other man in this country that we now have what remains of our heritage of wild life.

All through the years he was a prolific writer, and there is given in a footnote[1] a partial list of the books that flowed from his pen.

To all those who knew him well he was a splendid and loyal friend, and behind the hundreds of admirers who attended his final services, stand the mute inhabitants of our forests and uplands, who found in him a stout-hearted and able defender.

FAIRFIELD OSBORN

SCIENTIFIC EVENTS

THE DENVER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

REMARKABLY low railway excursion rates will be in effect at the time of the Denver meeting of the American Association for the Advancement of Science, from June 21 to 26. For example, a 21-day round-trip ticket from Chicago to Denver will cost only $34.20, with $14.52 additional for a lower Pullman berth. The corresponding fares from Washington, D. C., will be $78.65 and $25.52, respectively. Even from Boston railway fare and Pullman to Denver and return will be only $93.35 and $28.00.

Time schedules have been shortened as much as fares have been reduced. One may now leave Chicago in the early evening on the Burlington Zephyr or the Union Pacific City of Denver and arrive in Denver at about nine o'clock the next morning. The return journey is correspondingly convenient. If the point of departure is New York or Washington, one may leave in the late afternoon or in the evening, arrive in Chicago the next day, and be in Denver the following morning. Therefore, only one day is spent in traveling half way across the continent. And at about the same cost as by railway one may go by plane from Washington or New York to Denver between morning and evening.

By motor the journey requires a much longer time but is cheaper and in certain respects more interesting. The principal highways are excellent, particularly west of the Mississippi River. Service stations, garages, hotels and good tourist camps are found at frequent intervals. Splendidly graded and paved roads lead out of Denver into the heart of the Rocky Mountains. In Rocky Mountain National Park a new paved road ascends by easy grades to the top of the continental divide, along which it extends for several miles. At its maximum altitude it rises to 12,300 feet, and for miles it furnishes a superb view of rugged mountain scenery. Those who do not drive their own cars may also enjoy motoring in the mountains, for buses regularly carry passengers over all the principal scenic routes.

Since the Pacific Division and the Southwestern Division both join in the Denver meeting, the first time the association and its two divisions have met together, eastern scientists will have an exceptional opportunity of meeting and conferring with scientists from the western part of the country, disproving, at least in the case of scientists, the words of Kipling:

> Oh, East is East, and West is West,
> And never the twain shall meet.

F. R. MOULTON,
Permanent Secretary

THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

THE thirty-first annual meeting of the American Society of Agricultural Engineers will be opened at the University of Illinois for registration on Sunday afternoon, June 30. The program of the college division is scheduled for the first day of the meeting, June 21. General sessions will be limited to two one and a half hour periods on Tuesday and Wednesday, June 22 and 23. The technical sessions will occupy the remainder of those two mornings and Thursday morning, June 24.

[1] Thirty Years War for Wild Life; Two Years in the Jungle; Our Vanishing Wild Life; Wild Life Conservation in Theory and Practice; Taxidermy and Zoological Collecting; Camp Fires on Desert and Lava; Camp Fires in the Canadian Rockies; The Minds and Manners of Wild Animals; A Wild Animal Round-up; Wild Animal Interviews; Old-Fashioned Verses; The Man who Became a Savage.

The afternoons have been left open for individual contacts, inspection trips and special group meetings. The annual dinner is to be held on Wednesday evening and is to be followed by a dance. Other entertainment features planned include an illustrated lecture on Sunday evening, a picnic on Monday evening, an exhibit of plows on Tuesday afternoon and illustrated talks on Tuesday evening. Special entertainment is being planned for women and children during other hours.

Group discussions in the College Division session will be held on education, extension and research. Curricula, subject-matter, service courses, summer camps or courses, administration, graduate work, relations with the Society for the Promotion of Engineering Education and agricultural engineering work will be discussed in the opening program devoted to education. Agricultural engineering extension is to be covered from the angles of relation to other extension work, extension methods, educating employees of agricultural engineers, the vocational program, the 4-H Club program, publications and the U. S. Department of Agriculture Bureau of Agricultural Engineering. Research consideration will be concentrated on project presentation, graduate research and experiment stations. The committee on extension and the student group have scheduled special sessions to run concurrently during a part of the main meeting.

At the opening meeting on Tuesday there will be an address of welcome, the president's annual address and one outside speaker. Another outside speaker and the recipient of the McCormick Medal award will address the general session on Wednesday morning.

The Farm Structures Division will discuss farm housing, the agricultural engineer's responsibility in the promotion of better farm buildings, and papers on individual structural problems and developments. The Power and Machinery Division will give special attention to "The Farm Tractor Fuel Problem," "Quick Attachable and Detachable Power Farming Equipment" and "Natural and Artificial Curing of Forage Crops." The Rural Electric Division will offer sessions on extending electric service in rural areas, assisting the farm customer and electric service for the farm family. In the Soil and Water Conservation Division a wide variety of papers on irrigation, drainage, erosion control and land use problems will be presented.

THE AMERICAN DOCUMENTATION INSTITUTE

THE American Documentation Institute has been incorporated on behalf of leading national scholarly, scientific and informational societies to develop and operate facilities that are expected to promote research and knowledge in various intellectual fields.

A first objective of the new organization will be to develop and apply the new technique of microphotography to library, scholarly, scientific and other material. It will be able to conduct publication by various methods as required by cooperating organizations.

Organized as a Delaware corporation "not for profit" but for educational, literary and scientific purposes, the new organization resulted from a meeting attended by delegates from national councils, societies and other organizations in Washington on March 13. The board of trustees elected consists of: Dr. Robert C. Binkley, Western Reserve University; Dr. Solon J. Buck, director of publications, National Archives; Watson Davis, director, Science Service; Dr. James Thayer Gerould, librarian, Princeton University Library; Dr. Ludvig Hektoen, chairman, National Research Council.

Such a national organization was foreseen as an outcome of Science Service's documentation activities when they were begun in July, 1935, with grants from the Chemical Foundation and conducted with the cooperation of the U. S. Naval Medical School, the Library of the U. S. Department of Agriculture, the Bureau of the Census, the Works Progress Administration, the Library of Congress and other agencies.

The Bibliofilm Service has been conducted by Science Service in cooperation with the Library of the U. S. Department of Agriculture as a service to research workers, and auxiliary publication through microfilm has been conducted by cooperation with leading scholarly and scientific journals. The documentation activities of Science Service now will be transferred to the new American Documentation Institute.

GRANTS IN AID OF RESEARCH OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES

AT the April meeting of the American Academy of Arts and Sciences announcement was made of grants in aid of research from the Permanent Science Fund, as follows:

Professor Thomas Harper Goodspeed, University of California, Berkeley, $500 for technical assistance in the cytological, genetic and morphological examination of certain species of Nicotiana as an aid toward the completion of a monograph on that subject.

Professor Rachel Hoffstadt, University of Washington, Seattle, $250 for the purchase of animals and materials needed in a study of the viruses connected with Myxomatosis of rabbits and *Herpes simplex*.

Professor Norton A. Kent, Boston University, $250 to complete the installation of a 30-foot Littrow spectrograph.

Professor Gustav J. Martin, College of St. Teresa, Winona, Minn., $400 for technical assistance and materials needed in an investigation of the chemistry of sili-

cosis to be carried out in collaboration with Dr. L. U. Gardner, of the Saranac Lake Laboratory.

Professors George H. Parker and F. L. Hisaw, Harvard University, $300 for the construction of two open sea live-cars (for keeping dogfish) to be used in their studies of color changes and of reproduction in elasmobranch fishes.

Dr. Roberts Rugh, Hunter College, New York City, $125 for the purchase of materials to be used in a study of the relations and antagonisms of the pituitary and gonad hormones in Amphibia and Mammals.

Curtis W. Sabrosky, Michigan State College, East Lansing, $300 in partial support of a visit to certain European museums as a basis of study preparatory to the writing, not for academic credit, of a monograph on the dipterous family Chloropidae.

Dr. A. W. Sellards, Harvard Medical School, a sum not to exceed $325 for the purpose of having two colored plates (blocks) made to illustrate a paper on the histopathology of murine leprosy.

Dr. T. E. Sterne, Harvard College Observatory, $300 to aid in building highly sensitive thermocouples for measuring thermal radiation of stars.

Inquiries and applications for grants should be addressed to the chairman of the Permanent Science Fund Committee, Professor John W. M. Bunker, Massachusetts Institute of Technology, Cambridge, Mass.

OFFICERS AND MEMBERS ELECTED BY THE NATIONAL ACADEMY OF SCIENCES

AT the annual meeting of the National Academy of Sciences, held in Washington on April 26, 27 and 28, under the presidency of Dr. Frank R. Lillie, of the University of Chicago, Dr. Arthur L. Day, of the Geophysical Laboratory of the Carnegie Institution of Washington, was reelected vice-president for a further term of four years, Dr. H. S. Jennings, Henry Walters professor of zoology at the Johns Hopkins University, was reelected a member of the council, and Dr. Oswald Veblen, professor in the school of mathematics of the Institute for Advanced Study at Princeton, was elected to succeed Dr. Roger Adams, head of the department of chemistry at the University of Illinois.

Dr. August Krogh, professor of zoophysiology in the University of Copenhagen, was elected a foreign associate.

Members of the academy were elected as follows:

Section of Mathematics:

John von Neumann, Institute for Advanced Study, Princeton.

Section of Astronomy:

Seth Barnes Nicholson, Mount Wilson Observatory, Pasadena; Otto Struve, Yerkes Observatory, Williams Bay, Wis.

Section of Physics:

Arthur Jeffery Dempster, University of Chicago.

Section of Engineering:

Oliver Ellsworth Buckley, Bell Telephone Laboratories, New York City.

Section of Chemistry:

Duncan Arthur MacInnes, Rockefeller Institute for Medical Research.

Section of Geology and Paleontology:

Donnel Foster Hewett, U. S. Geological Survey.

Section of Botany:

Charles Thom, U. S. Department of Agriculture.

Section of Zoology and Anatomy:

Francis Bertody Sumner, Scripps Institution of Oceanography, La Jolla; Carl Gottfried Hartman, department of embryology, Carnegie Institution of Washington, Baltimore; Calvin Blackman Bridges, California Institute of Technology.

Section of Pathology and Bacteriology:

Leo Loeb, Washington University, St. Louis; Ernest William Goodpasture, Vanderbilt University; George Richards Minot, Boston City Hospital.

Section of Anthropology and Psychology:

Edward Chace Tolman, University of California, Berkeley.

SCIENTIFIC NOTES AND NEWS

THE Royal Society of Canada has awarded the Flavelle Medal to Dr. Frank Dawson Adams, dean emeritus of the faculty of applied science at McGill University. The award is made in recognition of his researches in geology, particularly those concerned with the ancient metamorphic rocks of Canada and the flow of rocks under pressure.

DR. ARMIN O. LEUSCHNER, director of the Students' Observatory and chairman of the department of astronomy at the University of California, received the honorary membership of the Rittenhouse Astronomical Society of Philadelphia at a special meeting held at the Franklin Institute on April 22. This was "in recognition of his outstanding contributions to the study of asteroids, comets and satellites." Following the ceremony Dr. Leuschner addressed the society on "The Long Range Prediction of the Motion of the Minor Planets."

AT the recent convention in Philadelphia of the Electrochemical Society, the Acheson Medal and Prize

of $1,000 was presented to Dr. Frederick Mark Becket, president of the Union Carbide and Carbon Research Laboratories, Inc., for his contributions to metallurgy. The Weston Fellowship of $1,000 was awarded to Garth L. Putnam, of Seattle, for an investigation of methods of depositing alloys of active metals from aqueous solution. The work will be done at Columbia University under the direction of the secretary of the society, Dr. Colin G. Fink. William A. Johnson, of Pittsburgh, was awarded the prize to young authors for a paper published jointly with Professor Allison Butts, entitled "Studies on Overvoltage."

THE American Chemical Society Prize of $1,000 has been awarded for 1937 to Dr. E. Bright Wilson, Jr., assistant professor of chemistry at Harvard University, for his experimental work in physical chemistry. The award, which is bestowed annually upon a chemist who is under thirty-one years of age and is of unusual promise, will be presented formally to Dr. Wilson at the ninety-fourth meeting of the society to be held in Rochester, N. Y., from September 6 to 10. The prize, which is maintained by Dr. A. C. Langmuir, of Hastings-on-Hudson, N. Y., and his brother, Dr. Irving Langmuir, provides for "recognition of the accomplishment in North America of outstanding research in pure chemistry by a young man or woman, preferably working in a college or university." The chairman of the jury of award was Dean Frank C. Whitmore, of Pennsylvania State College, president-elect of the society.

THE Medal of the Explorers Club, New York City, has been awarded to Rear Admiral Richard E. Byrd, in recognition of his "achievements in Arctic and Antarctic exploration." The presentation was made by Dr. Vilhjalmur Stefansson, president of the club, at a dinner given on April 20. The speakers included Thomas J. Watson, president of the International Business Machines Corporation; David Sarnoff, president of the Radio Corporation of America; Dr. Roy Chapman Andrews, director of the American Museum of Natural History; Captain Robert A. Bartlett, and Lowell Thomas. Sir Hubert Wilkins acted as toastmaster.

DR. THOMAS C. POULTER, director of the Armour Institute of Technology, Chicago, who was second in command of the Byrd Antarctic expedition of 1933–35, was presented on April 27 with a special gold medal by the National Geographic Society. Dr. Gilbert Grosvenor, president, made the presentation in the presence of Rear Admiral Richard E. Byrd. A luncheon followed. On the Byrd expedition Dr. Poulter's work included geophysical investigations, studies of ice conditions, magnetic soundings and observation of meteors and auroral phenomena.

CHARLES M. B. CADWALADER has been elected president of the Academy of Natural Sciences of Philadelphia. He succeeds the late Effingham B. Morris, who served as president from 1928 until his death last January. Since 1928 Mr. Cadwalader has held the office of managing director.

OFFICERS of the Electrochemical Society, which opened its meeting on April 28 in Philadelphia, were elected as follows: *President,* William G. Harvey, Aluminum Company of America; *Vice-presidents,* L. D. Vorce, New York City; R. L. Baldwin, Niagara Falls, N. Y.; O. W. Storey, Chicago, Ill; *Managers,* W. W. Winship, New York City; E. M. Baker, University of Michigan, and Sherlock Swann, Jr., University of Illinois; *Treasurer,* Robert M. Burns, New York City; *Secretary,* Dr. Colin G. Fink, Columbia University.

THE following officers were elected at the annual meeting of the American Society for Experimental Pathology: *President,* C. Phillip Miller, Chicago; *Vice-president,* Morton McCutcheon, Philadelphia; *Secretary* and *Treasurer,* Paul R. Cannon, Chicago; *Incoming Member of the Council,* Shields Warren, Boston. The next meeting of the society will be held in Baltimore in conjunction with the meetings of the Federation of American Societies for Experimental Biology.

DR. FREDERICK H. SAFFORD, of the University of Pennsylvania, has retired after serving for thirty-four years. He has been appointed emeritus professor of mathematics.

DR. RALPH LINTON, of the University of Wisconsin; Dr. George Herzog, of Yale University, and Dr. William Duncan Strong, senior ethnologist of the Bureau of American Ethnology of the Smithsonian Institution at Washington, will become in the autumn members of the department of anthropology of Columbia University. Dr. Franz Boas, who retired as head of the department with the title of professor emeritus on June 30 of last year, joined the faculty as lecturer in 1896 and became professor of anthropology in 1899.

DR. OTTO KRAYER, professor of pharmacology at the American University of Beirut, Syria, formerly of the University of Düsseldorf and the University of Berlin, has been appointed associate professor of pharmacology at the Harvard Medical School for five years beginning next September.

IVAN C. CRAWFORD, dean of the College of Engineering at the University of Idaho since 1923, has been appointed dean of the School of Engineering and Architecture at the University of Kansas. He succeeds Dean George C. Shaad, who died last July.

PROFESSOR JOHN T. STARK has been appointed chair-

man of the department of geology and geography of Northwestern University in place of Professor Charles H. Behre, who has asked to be relieved of the chairmanship to devote more time to research. Professor Stark will return to the university in September after a year spent in a field study of the geology of the Southern Pacific area and attendance at the International Geological Congress in Moscow in July. Professor Behre has been granted a year's leave of absence to attend the congress and to study European zinc deposits.

DR. W. M. WHYBURN, associate professor of mathematics at the University of California at Los Angeles, has been appointed acting chairman of the department of mathematics, to succeed Dr. Earle R. Hedrick, who was recently elected provost of the university.

DR. THOMAS B. COOLEY, professor of pediatrics at the Wayne University College of Medicine, Detroit, and chief of staff at the Children's Hospital of Michigan, has been named executive secretary to the council for pediatric research of the American Academy of Pediatrics. The council, which was established in 1935, will include, besides Dr. Cooley, Dr. Kenneth D. Blackfan, *chairman*, and Dr. Fritz B. Talbot, both of Boston; Dr. Alexis F. Hartman, St. Louis; Dr. Irvine McQuarrie, Minneapolis, and Dr. Oscar M. Schloss, New York City.

THE *Journal* of the American Medical Association reports that a special board has been appointed to advise the United States Conference of Mayors in the appointment of public health officers. Dr. Joseph W. Mountin, of the U. S. Public Health Service, is chairman of the board. Other members are: Drs. Allen W. Freeman, dean of the Johns Hopkins University School of Hygiene and Public Health; Wilson G. Smillie, professor of public health administration in the Harvard School of Public Health, recently appointed professor of public health and preventive medicine at Cornell University Medical College, New York City; Drs. Huntington Williams, health commissioner of Baltimore, and John L. Rice, health commissioner of New York City.

PROFESSOR DR. F. X. SCHAFFER, emeritus curator for geology and paleontology of the Natural History Museum of Vienna, is spending the spring and summer in California. He is at Pomona College for the month beginning on April 24, lecturing on topics in structural and historical geology, and will spend the week beginning on May 24 at Stanford University, giving five lectures on topics ranging from alpine structure to the Pleistocene glaciations of central Europe. Later he will become a member of the faculty of the summer session of the University of California at Berkeley.

DR. HENRY V. HOWE, director of the School of Geology of the Louisiana State University, and Dr. Richard J. Russell, professor of geography, will sail on May 22 for Russia, where they expect to attend the International Geological Congress to be held in Moscow from July 20 to 29. Dr. Howe will represent the American Association of Petroleum Engineers, and Dr. Russell will be a delegate from the Louisiana State University.

DR. ROBERT A. MILLIKAN, director of the Norman Bridge Laboratory of Physics of the California Institute of Technology, will lecture under the auspices of the American-Scandinavian Foundation at the Universities of Stockholm, Upsala, Oslo, Lund and Copenhagen during May.

AT Northwestern University, Professor Reginald A. Daly, of Harvard University, gave recently a series of six Harris Foundation lectures under the general title, "The Crust of the Earth."

DR. ROBERT BROOM, paleontologist of the Transvaal Museum, Pretoria, South Africa, gave a lecture on April 22 before a joint meeting of the New York Academy of Sciences and the American Museum of Natural History. His subject was "The Origin and Rise of Prehistoric and Recent Man."

SIR THOMAS HOLLAND delivered the Huxley Memorial lecture at the Imperial College of Science and Technology, South Kensington, on May 4. His subject was "The Permanence of Oceanic Depressions and Continental Elevations."

IN SCIENCE for April 30, the announcement of election to membership in the American Philosophical Society, Class III—Social Sciences, contains an unfortunate error in naming three foreign nominees as having been elected. There was no election of foreign members in this class at this meeting.

THE New York State Geological Association will hold its thirteenth annual meeting at Syracuse and vicinity on May 14 and 15. Professor Louis W. Ploger, president, and his associates at Syracuse University are planning two excursions, which will cover the stratigraphic section represented in the classic areas of central New York and which will illustrate the development of the physiographic features of the lake plain and plateau.

THE seventh annual Field Conference of Pennsylvania Geologists will be held in Bradford, Pa., on May 28, 29 and 30. The field trips will embrace a study of stratigraphy, structure and paleontology in the Upper Devonian, Mississippian and Lower Pennsylvanian in the Bradford quadrangle and in the Venango oil fields country. A physiographic trip west into the Lake Erie region will be made to study Presque Isle, modern beach phenomena and the elevated shore lines of glacial lakes Warren and Whittle-

sey. A visit will be made to a modern oil refinery and to oil leases where oil is being recovered by the water-flood and by air and gas repressuring. Copies of the final notice may be had by writing to Dr. Arthur B. Cleaves, secretary, Topographic and Geologic Survey, Harrisburg, Pa.

THE Minnesota Academy of Science held its fifth annual meeting at the University of Minnesota on April 17, with some 300 in attendance. At this meeting a new section, Science Education, planned for those whose interests lie primarily in the teaching of the sciences, was added to the two sections, physics and biology, into which the academy had hitherto been divided. In relation to this movement a Junior Academy of Science plan was initiated. The meeting opened with a general session, at which the speakers were Dean Walter C. Coffey and Drs. D. H. Davis, Irving McQuarrie and A. N. Wilcox, all of the University of Minnesota. The three sections held sessions for the reading of technical papers. In a public lecture before the entire group, Dr. H. K. Hayes, chief of the Division of Agronomy and Plant Genetics, University of Minnesota, closed the session with an illustrated talk, entitled "Some Observations on Life in China." The officers for 1938 include: *President,* Dr. W. S. Cooper, University of Minnesota; *Vice-president,* Professor E. T. Tufte, St. Olaf College; *Secretary-Treasurer,* Dr. H. K. Wilson, University of Minnesota; *Councilors,* Professor G. W. Friedrich, St. Cloud Teachers College; Dr. Louis H. Powell, St. Paul Institute; Dean E. M. Freeman, University of Minnesota; Dr. H. E. Essex, the Mayo Foundation. The academy will hold its next annual meeting at St. John's University, Collegeville, on April 23, 1938.

AN International Congress on the Testing of Materials was opened in London at the Institution of Civil Engineers on April 19. According to a report in the London *Times,* the congress, which was organized by the International Association for Testing Materials, was opened by Sir William Bragg, president of the Royal Society. Visitors from twenty-five countries were in attendance. In connection with this meeting a Joint Committee on Materials and Their Testing was set up to act as the British national organization for these matters. Representatives of twenty-two technical institutions and societies will serve on the joint committee, which has been formed on the understanding that it shall not absorb or replace in any way the activities of existing technical organizations. At the conclusion of the congress this committee took over the work of the British committee that had hitherto been entrusted with the activities in Great Britain of the International Association for Testing Materials. The chairman of the joint committee is Dr. H. J. Gough, and the secretary is C. W. J. Taffs, of the Institution of Mechanical Engineers. An exhibition of testing plant and apparatus was held at the Institution of Civil Engineers throughout the week in conjunction with the congress. The Department of Scientific and Industrial Research provided the largest group of exhibits, illustrating testing methods recently devised or developed in the department.

THE Australian Government has announced, according to *Nature,* that the work of the Council for Scientific and Industrial Research is to be extended in the interests of secondary industry generally. Since its establishment in 1926, the council has restricted its attention to problems of the primary producing industries, though no such restriction is imposed upon it by the Act under which it is constituted. It has always been assumed that an extension was only a matter of time in view of the contraction of world markets for primary products and the consequent pressure to increase the home market by expanding secondary industries. A recent decision to establish aircraft and motor production in the Commonwealth has intensified a growing demand for an extension of national scientific research, and an influential committee, including leading engineers and industrialists, is now at work preparing a definite scheme of work. Existing institutions will be utilized wherever possible, but it is fully recognized by the government that considerably increased financial obligations must be carried by it. A first step is to establish an agency for the maintenance of accurate fundamental standards of measurement and for the testing of master gauges for controlling precision manufacture. It is intended that in all developments intimate contact shall be maintained with, and guidance sought from, established British institutions engaged on work of the same type.

DISCUSSION

ON THE SIGNIFICANT FIGURES OF LEAST SQUARES AND CORRELATIONS

DR. F. R. MOULTON in the issue of SCIENCE for December 25, 1936, pointed out that the number of significant figures in the solution of a set of linear equations can not exceed the number of significant figures in the determinant A of the coefficients. By evaluating this determinant it is possible to make certain statements in advance concerning the reliability of the solution for the unknowns. I propose to add some thoughts to those expressed by Dr. Moulton, also to say a word further on the question raised by Dr. Joseph Berkson in SCIENCE for November 13, 1936.

A large class of problems in which these matters assume considerable theoretical and practical impor-

tance is the normal equations of least squares and correlations, though most of what I have to say will apply to any type of linear equations. It is customary to take advantage of the symmetry of normal equations by using Doolittle's method or some modification of it, any of which is but one of many possible algebraically rigorous procedures for "solving" the equations.

The first thing to note is that, given a set of normal equations, a short way of evaluating the determinant A is to proceed with the Doolittle solution or some favored modification of it, exactly as if one were solving for the unknowns. The value of A is then given by the product of certain numbers that naturally occur in the process of elimination; in the illustration to follow, A is the product of the leftmost numbers in the Roman numbered equations. So in dealing with normal equations it is hardly practicable to evaluate the determinant A in advance of solution, but it is helpful to see how its value is tied up with other features of the equations.

The following three normal equations can be used for illustration; a, b and c are the unknowns.

No.	(a)	(b)	(c)	(Const.)
I	$1.994009\,a$ +	$1.998994\,b$ +	$1.997000\,c$ =	11.982997
2	[$1.998994\,a$] +	$6.004004\,b$ +	$0.002000\,c$ =	14.013002
3	[$1.997000\,a$] +	[$0.002000\,b$] +	$3.000000\,c$ =	11.001000

The Doolittle solution is laid out as follows, six decimals being retained. In practice the bracketed terms would be omitted for brevity, and a sum column would be introduced for a check. The numbering and procedure follow O. M. Leland's "Practical Least Squares" (McGraw-Hill, 1921) Art. 147. In II; a has been eliminated; in III, a and b both have been eliminated.

No.	(a)	(b)	(c)	(Const.)
4	.....	$-2.003991\,b$	$-2.001992\,c$ =	−12.012954
II	0	$4.000013\,b$	$-1.999992\,c$ =	2.000048
5	.....	.....	$-1.999995\,c$ =	−12.000971
6	.....	.....	$-0.999989\,c$ =	1.000017
III	0	0	$0.000016\,c$ =	0.000046

The solution is practically frozen at the appearance of 0.000016 in column c of III. If but three or even four decimals had been carried, there would have been a complete cancellation at this point. Since 0.000016 contains only two figures, c will be determined to not better than two figures, no matter how many decimals are carried on the right; and the inaccuracy in c will be passed on to a and b in substitution.

The interrelations between the near vanishing of the determinant A, the near vanishing (0.000016) of the coefficient of c in III, the number of decimals carried and the number of significant figures in the values obtained for a, b, c, are now displayed. In the first place, the value of the determinant A is the product of the leftmost numbers in I, II and III, which in this case give

$$A = 1.994 \times 4.000 \times 0.000016 = 0.00013,$$

indicating that when six decimals are carried throughout the solution, not more than three can be significant in the values found for a, b, c, no matter in what order they are solved for.

The values of c found from III, b from II and a from I in turn are

$$a = 1.187844, \qquad b = 1.937500, \qquad c = 2.875000,$$

wherein, though only two figures are mathematically significant, the presence of all figures written is required for satisfaction of the equations to six decimals. This does not mean that we have somehow evolved accuracy out of inaccuracy; we can in fact round c off to 2.9 even, and find that the set of values

$$a = 1.150275, \qquad b = 1.950000, \qquad c = 2.900000$$

satisfies the normal equations just as well. Seeing this, we may wax bold and try $c = 3.15$ without disappointment, for it is a fact that the set

$$a = 0.774586, \qquad b = 2.075001, \qquad c = 3.150000$$

also satisfies the equations to six decimals. Discussion of this apparent vacillation will follow. Dr. Moulton referred to a similar case of instability in a problem in orbits.

The values of a, b and c that satisfy the normal equations absolutely are

$$a = 1, \qquad b = 2, \qquad c = 3,$$

as can be found by solving the normal equations with common fractions (equivalent to carrying all decimals) or by possessing the prescience that these particular ones were built up for illustration from the three equations

$$\begin{aligned} a + \quad & b + c = 6 \\ 0.997\,a + 1.002\,& b + c = 6.001 \\ 0\,a + \quad 2\,& b - c = 1 \end{aligned}$$

to which they are exactly equivalent. The latter set can be solved by inspection. The small angle between the first two planes, purposefully introduced, is responsible for the instability of a, b, c, and the freezing or near freezing of the normal equations.

So long as A differs from zero by any finite number, however small, there is one and only one value of a, one of b and one of c, that will satisfy the normal equations absolutely. These values can be found by holding to common fractions throughout the solution; and when this is done, any two procedures for solution will give identical and perfect results. There will nevertheless be a band of a values, a band of b values

and a band of c values, not necessarily of the same width, from which can be picked any number of sets a, b, c that will satisfy the equations to the number of decimals required—the greater the accuracy required, the narrower the bands. Moreover, for satisfaction of the equations to a specified number of decimals, the bands can be made wider and wider as A diminishes; in the limit when A is zero the equations are completely indeterminate, which means that a or b or c—one of them (two if A is of rank one)—can be assigned any value whatever for absolute satisfaction of the equations.

The width of each band is in fact the interval within which the corresponding unknown is significantly determined. Different methods of solution are merely devices for picking out from these bands different sets for a, b, c that will satisfy the equations as far as required. If A is small, the bands will be wide, and the results of two different methods of solution may appear alarmingly discrepant, yet be consistent with the equations to the last decimal. In such a situation the equations are said to be unstable, and we have already seen an example. Instability is identified by rather wide bands, and always occurs inseparably from near-indeterminacy and freezing.

The facts just cited have a bearing on interpolation. Suppose a curve with three adjustable parameters a, b, c, be put through three points in the x, y plane. The coordinates of the three points are exactly sufficient to fix a, b and c; and whether a, b and c enter the curve linearly or not, the three equations for determining them can be made linear by Taylor's series. Let now two of the three points be close together but still distinct; then the determinant A of the linear equations is not zero but is small, and the equations are unstable. The points, two of them being close together, and all with (say) four decimal accuracy in the y coordinate and with, for simplicity, absolute accuracy in the x coordinate, do not fasten a, b and c down to definite values, but only require them to lie within rather wide bands—bands of significance, they might be called.

For every value of (*e.g.*) a picked at random from the a band, values of b and c within very narrow limits are required from the b and c bands to satisfy the equations to the number of figures that are significant. Every set a, b, c so satisfying the given equations determines a curve that passes within the vertical distance $\pm$ 0.0001 of each point.

This brings up an angle to the problem easy to overlook: Dr. I. C. Gardner and Mr. L. W. Tilton, of the National Bureau of Standards, mentioned it to me in a recent conversation. For purposes of interpolation we would demand a curve that comes within $\pm$ 0.0001 of each point in order to preserve all the information supplied by the points. In other words, we would demand a set a, b, c that satisfies the equations to the full number of significant decimals, and this will require that the three unknowns a, b, c be mutually consistent to more places than are significant. It is not sufficient to take just any values of a, b and c from within their bands of significance; for interpolation, that is, for satisfaction of the equations as far as significant, we must have a set a, b, c consistent with the points to within 0.0001. For instance, in the solutions written earlier, we may not round off a, b and c to two figures on the pretext that they are significant to only two figures; the fact is that six decimals are required, as written, if the equations are to be satisfied to six decimals. It is permissible, even necessary, to pick one unknown blindly from its band, but the equations themselves must then be permitted to choose the other two. A solution by determinants may well require decimals considerably in excess of the number significant, as Dr. Berkson contended in SCIENCE for November 13: on the other hand, some of this extra labor may be avoided if the earlier unknowns are found by substitution (b from II, a from I, as in the above illustration).

One further item in connection with instability. It is advisable to test for it when it is suspected, but where the freezing was not decisive enough to discourage completion of the problem. By hindsight, it is at times advisable to make the test even when instability is not suspected. A test can be made by comparing the results of two solutions; if they are discrepant, yet both consistent with the equations to the last decimal, there is positive evidence of instability. If two solutions agree tolerably well, the equations may generally be considered stable, though this is only negative evidence.

A very sensitive test for stability is the comparison between the direct solution (substitution, as above) and the reciprocal solution, gotten by using the reciprocal matrix A^{-1} as a multiplier. In least squares and correlation work, the matrix A^{-1} is nearly always calculated anyhow as a matter of course, right along with the solution of the normal equations, since the elements of A^{-1} are the respective variance and product-variance coefficients of a, b, c, and are usually needed. The customary way of calculating A^{-1} is to solve the normal equations with the unit matrix

$$\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

in the constant columns, writing down the values obtained for the unknowns in the same order. Once obtained, the matrix A^{-1} is readily used as a multiplier for finding the values of a, b and c that satisfy any

constant column whatever (*cf.* R. A. Fisher, "Statistical Methods for Research Workers" (Blackie and Son, 1925, 1936) Art. 29). The reciprocal solution, like any other determinant solution, is apt to give spurious results in the case of near indeterminacy, and it is this very fact that furnishes the test of stability.

For the normal equations written above, the reciprocal matrix with two-figure accuracy turns out to be

$$A^{-1} = \begin{vmatrix} 141141 & -46962 & -93922 \\ -46961 & 15625 & 31250 \\ -93922 & 31250 & 62500 \end{vmatrix}$$

The large numbers themselves warn of instability. Used as a multiplier, the top row and the original constant column give

$$a = 141141 \times 11.982997 - 46961 \times 14.013002 - 93922 \times 11.001000 = 2.765577;$$

and in like manner the second and third rows give

$$b = 0.852883, \qquad c = 1.705766.$$

The glaring discrepancies between these values and the earlier solutions are evidence of instability, but of course no test was needed in this instance. If common fractions had been used, or all decimals retained, the reciprocal solution would have given $a = 1$, $b = 2$, $c = 3$, which satisfy the equations absolutely.

Some of the notions here expressed have grown from a few ideas brought to my notice by Dr. A. C. Aitken, of the University of Edinburgh, about two years ago; in particular, the suggestion of the reciprocal solution for comparison is his. Such notions concerning near indeterminacy and instability occur readily enough to mathematicians, but not so readily to other scientists and economists who have use for them. The reader will understand that only the algebraic features of the problem are here dealt with; physical significance of figures is another matter. It is interesting, I think, to see that there are both mathematical and physical aspects to the problem.

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PERANEMA AND "GRANTIA"

CONCERNING the second flagellum of *Peranema*,[1] I can only repeat that after prolonged study of normal active specimens under oil immersion I was not able to see any such structure. However, Lackey[2] and Hall[3] have already pointed out that this second flagellum can not be seen in the living animal and is not used in locomotion. My observations were confined to live specimens, and the flagellum is evidently observable only in stained specimens. I was obviously in error in doubting its existence on the grounds of its non-visibility in life. Since writing the article in question[4] I have been able to observe the vacuolar apparatus in *Peranema* and other euglenoid flagellates and I find that the recent accounts of this apparatus in *Peranema* are erroneous, as is likewise the standard text-book description of the vacuolar system of the Euglenida in general. The contractile vacuole of *Peranema* is a temporary vesicle which discharges into the gullet base and thus completely vanishes, having no continuity with the succeeding vacuole. As each vacuole reaches diastole there appear near it two or three small vacuoles. These are not, as usually supposed, secondary vacuoles opening into the main vacuole, but are simply the droplets whose fusion forms the next vacuole. As the current vacuole disappears, these droplets tumble together into the space which it occupied and unite to become the next vacuole. A similar state of affairs was found to hold for several other euglenoids, both green and colorless, studied.

Dr. de Laubenfels' correction, in the same number of SCIENCE, of an obvious error in the naming of the common little syconoid sponge of the Woods Hole vicinity is welcome, but unfortunately Dr. de Laubenfels omits to mention that *Scypha* is a synonym of *Sycon*. Sponges with the structure of the Woods Hole form have always up to the present been placed in the genus *Sycon* by sponge specialists, and the erroneous name *Grantia* was already corrected to *Sycon* (on the advice of Professor H. V. Wilson and myself) in the last editions of Pratt's "Manual of the Common Invertebrate Animals" and Drew's "Invertebrate Zoology." It now appears that the name *Scypha* has priority over *Sycon*, and hence it will unfortunately be necessary to change the name *Sycon* to *Scypha*. The form *Scypha* (*Spongia*) *coronata* given by de Laubenfels does not conform to the international rules of nomenclature, for a parenthesis can be used in this manner only to indicate a subgenus, as is certainly not the intention here. Consequently the name of the Woods Hole sponge (assuming that the specific identification is correct) should read *Scypha coronata* (Ellis and Solander) 1786, syn. *Spongia coronata* Ellis and Solander.

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A REMARKABLE SABRETOOTH-LIKE CREODONT FROM THE EOCENE OF UTAH

DIRECTOR AVINOFF, of the Carnegie Museum, has kindly sent me for description the lower jaw of a predaceous animal, the nature of which is not apparent

[1] SCIENCE, February 19, 1937.
[2] *Biol. Bull.*, Vol. 65.
[3] *Trans. Amer. Micro. Soc.*, Vol. 53.
[4] *Quart. Jour. Micro. Sci.*, Vol. 79.

first glance. Examination, however, proves that it one of the primitive suborders of the Carnivora, the reodonta, and the remarkable feature is the way in hich it has imitated the sabretooth cats of the true rnivora. The dental formula of the lower jaw is $C_{\frac{1}{1}}$ $P_{\frac{4}{4}}$ $M_{\frac{2}{2}}$. The second molar is a cat-like sectoral. he lower jaw has protective flanges from the anterior rt, which demonstrate that the upper canines were rge sabres. The position of the condyle of the mandible and the shape of the coronoid process show that this animal was far advanced in specialization equal to that of the White River *Eusmilus*, the most specialized of all the sabretooth cats. For this fossil the name *Apatælurus kayi* is proposed, the specific name in honor of Mr. J. Leroy Kay, of the Carnegie Museum, who made the discovery.

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SOCIETIES AND MEETINGS

THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

The Wisconsin Academy of Sciences, Arts and etters held its sixty-seventh annual meeting at the ilwaukee Public Museum, Milwaukee, Wisconsin, on pril 9 and 10, conjointly with the Wisconsin Archeogical Society and the Midwest Museums Conference. bout 125 persons attended the meeting.

After a short general session the papers to be read ere divided into two sections: Section A, devoted to apers dealing with archeological and museum subects; and Section B, devoted to papers concerning the everal sciences. Fifty-six papers were presented, nd these were divided equally between the two sections. Mr. Charles E. Brown, director of the Wisonsin Historical Museum, served as chairman of ection A, and Dr. Chancey Juday, president of the cademy, presided over Section B.

The academy held its annual business meeting at :30 o'clock on Friday afternoon, at which time it lected twenty-three new members, accepted the resignations of Mr. Walter M. Smith, librarian, and Dr. R. . Shrock, secretary-treasurer, and elected Mr. Gilbert H. Doane, librarian, and Dr. Loyal Durand, Jr., secreary-treasurer.

The annual academy dinner was held at the Hotel chroeder at 6:00 o'clock on Friday evening, with 44 n attendance. Immediately after the dinner, members and guests returned to the museum, where Drs. oel Stebbins and A. E. Whitford, of the Washburn bservatory, presented the evening lecture on "Gadets and Galaxies," in which they demonstrated the use f the photo-electric cell in the study of stars and alaxies. The audience numbered over 150.

Officers for 1937–38 and 1938–39 are as follows:

President, Chancey Juday, University of Wisconsin.
Vice-president in the Sciences, Paul W. Boutwell, Beloit College.
Vice-president in the Arts, S. C. Wadmond, Delavan, Wisconsin.
Vice-president in Letters, Julia Grace Wales, University of Wisconsin.
Secretary-Treasurer, Loyal Durand, Jr., University of Wisconsin.
Librarian, Gilbert H. Doane, University of Wisconsin.

R. R. Shrock,
Secretary-Treasurer

THE ARKANSAS ACADEMY OF SCIENCE

The twenty-first annual meeting of the Arkansas Academy of Science was held at the University of Arkansas, at Fayetteville, on March 26 and 27.

The annual public lecture was presented by Dr. T. S. Painter, of the University of Texas, and the title of the address was "Recent Developments in Our Knowledge of Chromosome Structure and Their Bearing on Genetics." The lecture was presented under the combined auspices of the academy and the University of Arkansas Sigma Xi Club.

A feature of the meeting was a Conservation Symposium. The following speakers contributed to the meeting as follows: "The Conservation of the Minerals of Arkansas," G. C. Branner, state geologist; "Soil Conservation," G. E. Riddell, assistant state coordinator, Soil Conservation Service; "Wild Fowl Conservation," Robert Smith, White River Migratory Waterfowl Refuge, U. S. Biological Survey; "Relation Between Forest and Game Preservation," H. A. Miller, White River Migratory Waterfowl Refuge, U. S. Biological Survey; "Forestry in a Conservation Program," R. D. Stevens, University of Arkansas; "Conservation Aspects of the Resettlement Administration," T. Roy Reid, regional director, Resettlement Administration, Region 6.

The following officers were elected for 1937–38: *President,* W. C. Munn, Magnolia A. and M. College; *Vice-president,* T. L. Smith, College of the Ozarks; *Secretary,* L. M. Turner, University of Arkansas (re-elected); *Treasurer,* W. R. Horsfall, University of Arkansas (re-elected); *Editor,* I. A. Wills, John Brown University.

The 1938 meeting will be held at the College of the Ozarks, at Clarksville.

Lewis M. Turner,
Secretary

A SYMPOSIUM ON THE CALCULUS OF VARIATIONS

A SYMPOSIUM on the calculus of variations was held at the University of Notre Dame on April 7 and 8. The first of the four meetings under the direction of Dr. Marston Morse, of the Institute for Advanced Study, Princeton, was opened by some remarks of Dr. Karl Menger, of the University of Notre Dame, who described as the purpose of the symposium the establishment of further relations between the different directions in calculus of variations; metric methods which yield general existence theorems, as well as a new proof of Euler's equation, may be one of the means. Dr. Gilbert A. Bliss, of the University of Chicago, presented a paper on "Normality and Abnormality in the Calculus of Variations." Dr. Lawrence M. Graves, of the University of Chicago, spoke on "The Reduction of Certain Problems in the Calculus of Variations to the Problem of Bolza."

At the second meeting, which was directed by Dr. G. A. Bliss, Dr. Tibor Radó, of the Ohio State University, presented a paper on "The Method of Variation of the Independent Variable." He demonstrated how this method could be successfully applied to the solution of the problem of Plateau. In the discussion, Dr. S. Lefschetz and other speakers emphasized the importance of the application of the modern methods to two-dimensional problems. Dr. William T. Reid, of the University of Chicago, used expansion methods to obtain sufficient conditions for the one-dimensional problems in the calculus of variations. The last speaker of the second meeting was Dr. Sumner B. Myers, of the University of Michigan, who treated certain aspects of differential geometry in the large.

The following morning, on which Dr. Solomon Lefschetz, of Princeton University, presided, Dr. Marston Morse spoke on "Abstract Variational Theory." He explained his new general theory of stable curves, divided into a group-theoretical and a metrical part. Dr. Edward J. McShane, of the University of Virginia, presented his general proofs of existence theorems.

In the afternoon, under the direction of Dr. Lincoln LaPaz, of the Ohio State University, Dr. Karl Menger discussed the applications of his metric methods to the proof of very general existence theorems. The rest of the meeting was devoted to applications of the calculus of variations. Dr. Charles F. Roos, of New York City, dealt with applications to economics, in particular with problems to the building industry; he derived formulas which had yielded predictions for the last three years. Dr. Lothar W. Nordheim, of Purdue University, spoke on "Variational Problems in Quantum Electrodynamics." Dr. Arthur E. Haas, of the University of Notre Dame, presented a paper on "The Variation Principles of Maupertuis and Fresnel, and the Relation between Wave Mechanics and the Theory of Relativity."

On the first evening Dr. Lefschetz gave a popular lecture on the subject "What is Topology?"

The meeting was attended by a group of more than fifty visitors from all parts of the country.

KARL MENGER

SPECIAL ARTICLES

RESTORATION OF CARBOHYDRATE OXIDATION IN DIABETIC TISSUE IN VITRO[1]

SINCE Houssay's notable demonstration that pancreatic diabetes in the experimental animal is ameliorated by the removal of the hypophysis, it is no longer possible to regard diabetes mellitus as conditioned solely by a lack of insulin or to consider that normal carbohydrate metabolism is governed by this hormone alone. It is now generally held that the proper utilization of carbohydrate is under the control of two or more internal secretions in a delicate balance, insulin on the one hand, and on the other, a secretion or secretions elaborated in the pituitary or in other glands, as the adrenals (Long, Lukens) under hypophyseal control.

Experiments on the whole animal of various species have shown that the removal of the hypophysis following pancreatectomy results in a diminution or absence of glycosuria and ketosis, especially under fasting conditions, during which low blood sugar values are also found. Carbohydrate metabolism in these animals is not, however, entirely normal. Chambers, Sweet and Chandler[2] have shown that while the basal respiratory quotient is definitely higher in the Houssay dog than in pure pancreatic diabetes, they show an inconstant rise in the level of the respiratory quotient on receiving glucose.

Tissues removed from the same group of Houssay animals and studied in this laboratory in the Barcroft-Warburg micro-respiration apparatus have shown a more marked return to the normal than might have been anticipated from the results obtained with the whole animal. For example, strips of skeletal muscle

[1] From the Department of Medicine, Cornell University Medical College and The New York Hospital, New York City.

[2] Chambers, Sweet and Chandler, *Proc. Am. Physiol. Soc.*, Memphis, April, 1937.

were found to retain the ability to resynthesize added lactate in entirely normal fashion, in contrast to similar tissue from depancreatized dogs, which lose this function.[3] In addition, basal respiratory quotients as well as those obtained in the presence of lactate were definitely higher than in the diabetic animal. More recently, a comparison of slices of cardiac muscle of normal, depancreatized[4] and Houssay dogs (unpublished data) revealed an even more striking return to normal carbohydrate metabolism in the last group, to judge by basal respiratory quotients equal to those of normal animals, and a rise to the neighborhood of unity on the addition of glucose and lactate.

From the superiority of the carbohydrate metabolism of these excised tissues of the Houssay dog, as compared with the behavior of the whole animal, it might be inferred that there still exists in the whole animal inhibitory factors, from which the tissues on removal from the body are released. The potentialities for carbohydrate metabolism can then be more fully realized. They would seem, from these findings, to be independent of insulin, provided the other factors—arising from the pituitary or from organs controlled by the pituitary—are absent as well. Even in excised cardiac tissue from depancreatized dogs, something of the same nature can be shown. For, although these tissue slices have lost the ability to respond to the addition of glucose or lactate by an elevation of respiratory quotient, their basal quotients may be quite high—up to 0.89—indicating an ability to oxidize preformed carbohydrate; whereas, in the heart-lung preparation, according to the carefully controlled experiments of Cruickshank and Startup,[5] the respiratory quotient of the diabetic heart is always around that of pure fat oxidation—0.70.

The main purpose of this note is to report in brief experiments carried out in this laboratory with Eugene Cohen and Muriel Malam, which may have a bearing on the rôle of insulin and these hypothecated inhibitory substances in carbohydrate metabolism. Cardiac tissue was removed from completely depancreatized dogs for study in the Warburg apparatus. The dogs received no insulin at any time, and were fasted for three days prior to the experiments, which were carried out seven days after pancreatectomy. The tissues were prepared with sterile precautions, and one batch run at the start to determine its initial respiratory metabolism in a non-nutrient Ringer-phosphate solution and in the presence of 0.2 per cent. glucose. The rest of the tissue was incubated at 37.5° C. in sterile Ringer-phosphate pH 7.4 containing 0.2 per cent. glucose. Similar respiratory measurements were made at the end of five and ten hours. The results have been assembled in Table I.

TABLE I

THE RESPIRATORY QUOTIENT OF EXCISED CARDIAC TISSUE OF DIABETIC DOGS FOLLOWING PROLONGED INCUBATION IN RINGER-GLUCOSE-PHOSPHATE AT 37.5° C.

Dog no.	Medium	Respiratory quotient						O_2 cons. cc/gm/hr.		
		initial		after 5 hrs.		after 10 hrs.		0	5	10
1	non-nutrient	0.77		0.84		0.90		0.72	0.54	0.51
	glucose 0.2 per cent.		0.74		0.89		0.94	0.62	0.46	0.49
2	non-nutrient	0.74		0.81		0.81		0.71	0.87	0.72
	glucose 0.2 per cent.		0.73		0.82		0.88	0.82	0.89	0.68
3	non-nutrient	0.72		0.77		0.85		0.84	0.43	0.37
	glucose 0.2 per cent.		0.72		0.92		1.11	0.74	0.55	0.39
4	non-nutrient	0.78		0.82		0.78		0.64	0.95	1.00
	glucose 0.2 per cent.		0.78		0.86		1.00	0.65	1.06	0.65
5	non-nutrient	0.76		0.85		0.90		0.44	0.38	0.34
	glucose 0.2 per cent.		0.71		0.94		1.05	0.47	0.43	0.43
Average diabetic	non-nutrient	0.75		0.82		0.85		0.67	0.63	0.59
	glucose 0.2 per cent.		0.73		0.89		0.99	0.66	0.68	0.53
Normal	non-nutrient	0.81		0.89		0.89		0.47	0.68	0.57
	glucose 0.2 per cent.		0.89		0.92		1.00	0.54	0.74	0.86

It is apparent that a definite change in the metabolism of the tissues occurred with prolonged incubation under these conditions. The capacity to oxidize carbohydrate, judging from the higher basal quotients and the definite response to glucose, has become quite like that of normal cardiac tissue. In the tissue from the normal animal a similar increase in the degree of carbohydrate metabolism can also be seen. Attention should be called to the fact that, with prolonged exposures, the level of oxidation in two out of five experiments fell appreciably; although the effects on the respiratory quotient do not appear to be dependent on this fact, to judge from the experiments in which the fall was trivial. Preliminary experiments with other tissues, such as voluntary muscle and kidney, indicate that this phenomenon is not confined to the heart.

[3] Shorr, Richardson and Sweet, *Am. Jour. Physiol.*, 116: 142: 1936.

[4] Shorr, Malam and Richardson, *Proc. Am. Physiol. Soc.*, Memphis, April, 1937.

[5] Cruickshank and Startup, *Jour. Physiol.*, 81: 153, 1934.

On the basis of these experiments, one is tempted to draw certain inferences. It is very unlikely that there is any significant amount of insulin left in the tissues seven days after pancreatectomy, in view of the careful work of Best, Jephcott and Scott.[6] It may be postulated that there is present, initially, some factor or factors, inhibitory of carbohydrate oxidation, not by direct neutralization of insulin, but by a depression of some phase in the chain of carbohydrate oxidation. Unchecked by insulin in the diabetic organism, the effect is profound. During the incubation at body temperature *in vitro,* this inhibiting factor is somehow destroyed or lost to the cell. Whereupon the tissue can resume its full primitive potentiality for carbohydrate oxidation, without the need for participation of insulin in the process. In the normal tissue also, there is a factor limiting the extent of carbohydrate metabolism, whose influence wears off on incubation. Whether or not the increased carbohydrate oxidation in this case is due to unchecked insulin action or is independent of it can not be judged from this experiment. Basically, oxidation of carbohydrate can be divorced from the action of insulin, whose main function in the organism may be to act in an opposite direction to the inhibitory factors. This conception would fit in very well with the phenomena of the Houssay dog, or the adrenalectomized-pancreatectomized animal, as well as with the findings on the tissues of the Houssay dog reported above. It would help clarify the situation in human diabetes, where a pancreas, histologically intact and containing insulin, may be present. It would help explain the tenacity with which some tissues, particularly muscle, hold on to their carbohydrate stores in conditions such as fasting, instead of prodigally using up this easily oxidized substance.

But such tempting inferences must be tentative until there is much more in the way of experimental data. The phenomena reported could be due to a pathological state in the tissues, attendant on prolonged exposure to these relatively unphysiological conditions, or to changes in cell permeability. That the tissue may be damaged to some extent by the long period of incubation is apparent from the occasional depression of respiration which takes place.

It is the aim of experiments now going on in this laboratory to evaluate these several possible explanations of an interesting phenomenon.

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[6] Best, Jephcott and Scott, *Am. Jour. Physiol.*, 100: 285, 1932.

TRICHOMES OF INCIDENTAL IMPORTANCE AS CENTERS FOR LOCAL VIRUS INFECTIONS

STUDIES have been made to evaluate the importance of trichomes and other epidermal cells as points of entry for virus that causes local infections when the inoculum is wiped over the leaves of suitable species. Although the trichomes do serve as centers for local virus infection, their importance in comparison with other cells of the epidermis seems to have been overestimated.

Inoculations were made through the trichomes by cutting them from the leaf surface or mutilating them with a fine instrument while immersed in a small drop of fresh virus extract under a dissecting microscope at magnification 28×. Cutting 2,290 trichomes from leaves of *Nicotiana sylvestris* Spegaz. and Comes resulted in 2.2 per cent. positive local infections. Inoculations by mutilation of all the trichomes on small areas of leaves of *N. sylvestris, N. glutinosa* L. and *N. rustica* L. resulted in 35, 22 and 12 per cent. of the expected local infections, respectively. The expected number of infections was determined by wiping the inoculum over the opposite halves of the leaves on which the above tests were made.

Since trichomes are very sparse on the leaves of pepper, *Capsicum frutescens* L., it was possible to avoid them and inoculate small areas of the epidermis. These inoculations were made under a dissecting microscope by using an elbow bent in a fine flexible wire or a padded pin head to lightly rub the inoculum over the epidermis. Care was taken to avoid bruising or breaking trichomes or making wounds which might be apparent at this magnification. The ordinary cells of the epidermis were very susceptible to inoculation by a very light rubbing, since approximately the expected number of local infections was obtained.

The right halves of 47 *Nicotiana sylvestris* leaves were wiped with virus-free water and allowed to stand from two to six days before inoculation of the entire leaf by wiping. The first wiping of the right halves of the leaves destroyed about 95 per cent. of the trichomes and there was very little evidence that other cells of the epidermis had been injured. After inoculation it was found that the number of necrotic lesions was reduced 6.8 per cent. on the right halves of the leaves which were wiped twice in comparison with the left halves of the leaves which were wiped only at the time of inoculation. This experiment was repeated with 43 leaves, except that fine carborundum dust and water were used for the first wiping of the right halves of the leaves. This wiping destroyed about 98 per cent. of the trichomes, and many of the ordinary cells of the epidermis were severely injured or killed. After

culation it was found that the number of necrotic ons was reduced 31 per cent. on the right halves ich were wiped twice in comparison with the left ves which were wiped only at the time of inocula-n.

If trichomes were of major importance as points entrance for inoculum, their destruction would be pected to cause a greater reduction than 6.8 per t. in the number of local infections when leaves e inoculated later. The importance of the ordinary ls as points of entrance for inoculum is evident, ce severe injury to some of them reduced the num- of local infections 25.2 per cent. as compared to 6.8 per cent. reduction when practically all the homes were severely injured or destroyed and little ury was observed in the ordinary cells.

Pepper and *Nicotiana sylvestris* leaves have ap-oximately 16 and 346 trichomes per square centi-ter, respectively. When pepper leaves were inocu-ed by wiping in the usual manner, 82.4 per cent. of local infections showed no relation to trichomes. contrast on leaves of *N. sylvestris* 39.87 per cent. of lesions showed no relation to trichomes, 20.26 per t. of the lesions had a broken trichome in the periphery of the lesion and 39.87 per cent. had a broken trichome in the center of the lesion.

It was pointed out earlier in this note that 35 per cent. of the expected number of lesions resulted on leaves of *Nicotiana sylvestris* when all the trichomes on small areas were inoculated without injury to other epidermal cells. This 35 per cent. is consistent with the 39.87 per cent. of the total lesions observed to have trichomes in their centers on the wiped leaves, and for this reason these lesions on the wiped leaves are considered to be the result of inoculation through broken trichomes. The 20.26 per cent. of the lesions having a broken trichome in their periphery are considered to be the result of an inoculation through an epidermal cell near to the trichome.

It is evident that many ordinary epidermal cells serve as infection centers and that the larger percentage of infections through trichomes of *N. sylvestris* is due to the greater number of trichomes on a given leaf area as compared to pepper.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE DEVICE FOR MEASURING THE ABSORPTION RATES OF SOILS

A fundamental factor in determining the extent of n-off and erosion from western watersheds in times torrential rain or rapid melting of snow is the rate which the soil will absorb surface water and conduct into underground channels, where it ceases to be an sive agent but percolates to the vast soil and rock ervoirs which feed the springs. Recognizing the portant rôle played by this soil function in water-ed management, the Intermountain Forest and nge Experiment Station has developed an appa-tus to measure the rate of absorption with a mini-um of disturbance to the soil. The unit is inexpen-ve to construct, simple to operate, and its small size d light weight permit the study of soils in their disturbed state on areas accessible only by foot.

The apparatus includes a water reservoir (Fig. 1 *a*), de by grinding the bottom from a quart bottle, and distributor (*b*), built of ¼-inch brass pipe and fit-gs, which delivers water in a thin sheet to the upper le of a one-square-foot plot enclosed by suitable ffle plates (*c*). As the water flows over the plot me is absorbed at a rate determined by the nature the soil, the steepness of the slope and the kind of getation present; and the excess passes into the run-trough (*d*) and a manually operated tipping bucket), where its rate of flow is measured. The difference between the rate of application and the rate of run-off is the rate at which water has been absorbed by the soil.

The rate of application is controlled by a globe valve and is determined by observing the time required for successive measured portions of 300 cc each, contained in cans (*f*), to pass through the distributor. At the start of a run, the reservoir is filled to the level of the pointer (*g*) and one measured portion is added. When, after the application is started, the water level again drops to the tip of the pointer, the delivery of one measured portion is indicated and the elapsed time is recorded. Another measured portion is then added and the run continued. The variation in head caused by the intermittent addition of portions of water has no significant effect upon the rate of flow through the system.

At the termination of each time interval during which a measured portion of run-off has been applied to the plot, the tipping bucket is tipped so that the run-off from the next 300 cc application is caught in a separate container. Subsequent measurements of these run-off portions indicate the rate of run-off, and by subtraction from the rate of application, the rate of absorption is determined.

After the first one or two minutes of the run, the absorption rate of the plot becomes nearly constant, and can be compared directly with corresponding rates on other plots. Replicate determinations on the

same or adjoining plots are easily made, and consistently accurate results are obtained. The unit has proved its worth in two recent studies by this station. In a comparative study of plots supporting a single range plant and adjacent barren plots, use of the unit

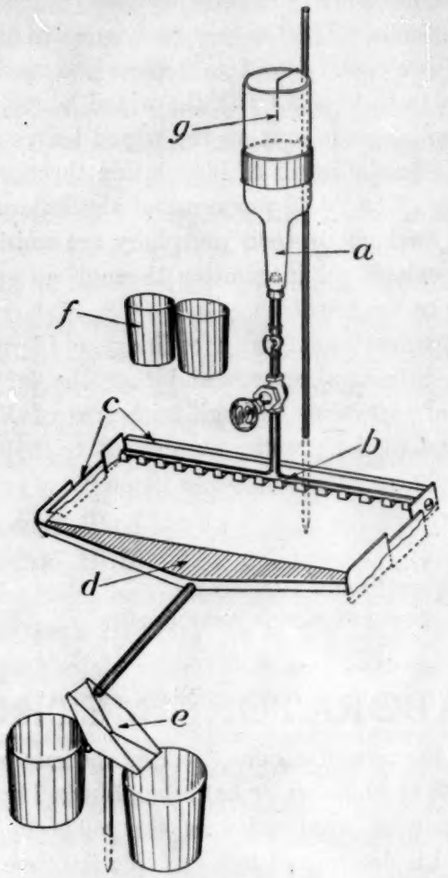

FIG. 1

has indicated that fibrous-rooted plants, such as grasses and mesophytic forbs, are approximately 2½ times more effective in promoting absorption of surface water than are tap-rooted species typical of depleted range.[1] Another study indicated that the rate of absorption by the granitic soils of the Boise River watershed was influenced much more by organic matter content than by either moisture content or textural variations. Such studies emphasize the importance of an adequate plant-cover in range-watershed management, both directly in promoting absorption and indirectly in building up the soil organic matter.

A limited supply of complete specifications for the construction and operation of the above apparatus, for use by persons interested in this technique, are available upon request to the Director, Intermountain Forest and Range Experiment Station.

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[1] C. Kenneth Pearse and Samuel B. Woolley, *Jour. Forestry*, 34: 884–887, 1936.

BOXES FOR STUDY SKINS

DOUBTLESS many laboratory instructors in mamm- ogy and ornithology have felt the need for a protect- cover for the study skins, which received rough tre- ment by careless and awkward students. This need greater when the skins that must be used are rec- skins. Such was our problem when we discovered th two new products, Plastocele and Pyralin, can be c or sawed and cemented.

Providing a skilful student with this materi acetone and study skins he made 26 boxes for ma- mals ranging in size from mice to marmots at average cost per box of 35 cents for material and cents for labor. The cement made by dissolving sm waste pieces and the sawdust in acetone sealed the se tions firmly together, making airtight containers th are light, transparent and durable. Additional box made for mammal and bird skins and the entire s used during our winter quarter show only the ine table finger marks and light scratches, and the latt do not obstruct the view of the snug-fitting, fully pr tected skin within.

Plastocele and Pyralin are practically identical f these boxes, the former costing slightly more. W learned about these two products of the du Pont Vi coloid Company at Arlington, N. J., from Dr. Shi linger, of the United States Department of Agricu ture, who suggested their use for museum jars.

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